

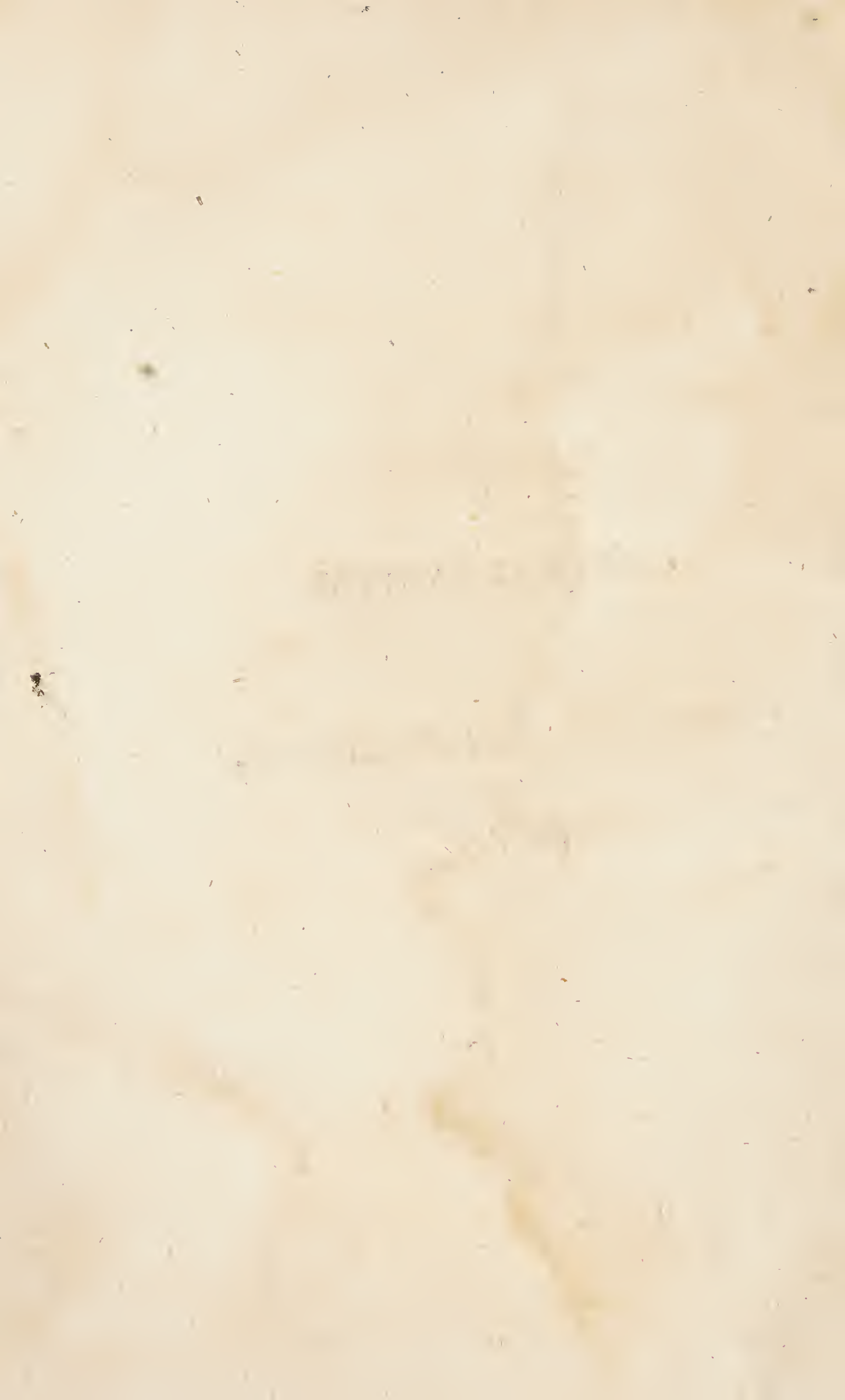
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GENERAL SYSTEM
OF
CHEMICAL KNOWLEDGE,
&c. &c.



A
GENERAL SYSTEM
OF
CHEMICAL KNOWLEDGE;
AND ITS
APPLICATION
TO THE
PHENOMENA OF NATURE AND ART.

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of many Academies, &c.

IN ELEVEN VOLUMES.

TOGETHER WITH A SET OF SYNOPTIC TABLES, IN LARGE FOLIO.

TRANSLATED FROM THE ORIGINAL FRENCH,
BY WILLIAM NICHOLSON.

VOL. II.

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A
S Y S T E M
OF
CHEMICAL KNOWLEDGE.

SECTION THIRD.

Concerning Burned Bodies, Oxides, or Acids.

ARTICLE I.

*On Combustion. General Considerations respecting the
Oxides, and the Acids.*

1. WE have seen, in the fourth and fifth articles of the preceding section, that combustion, which is considered by society in general, as a collection of light, of heat, and of motion, decomposing such bodies as they act upon, is shown by chemists, to be a true combination of the combustible substances with oxygen, and that it more especially consists in this combination; that oxygen gas, by losing its form, and

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suffering its solvent to escape in light and heat, most commonly assumes the solid state of the combustibles,—is fixed more or less strongly,—unites with them in various proportions, and adheres with different degrees of power; that sometimes, on the contrary, the bodies themselves are fused, volatilized, and dissolved in the oxygen gas, so as to partake of its elastic fluidity; that we can form a judgment of the degree of the solidity of the oxygen in burned bodies, by estimating the quantity of caloric thus disengaged; that the oxygen having different degrees of elective attraction for the various combustibles, it is possible, by means of some of these, to decompose others which have already been burned; that this phenomenon, termed in general decomposition, is favoured by the contact of light; that an accumulation of caloric, more especially when it acts at the same time as light, is frequently capable of unburning oxygenated bodies, without the addition of other combustible matters; that oxygen not only unites in different doses with each of the combustible bodies, under like circumstances, but also combines, in various proportions, with each of them singly, according to the manner in which the combustion is effected; that the different portions of oxygen may be supposed, in thought, to be divided in the body thus saturated, in the same manner as they can be separated and united; that these adhere with different degrees of force, and, in general, according to
one.

one of the laws of attraction in the inverse ratio of the saturation. Those data, obtained by the labours of the modern French chemists, lead us to a knowledge of the properties of burned bodies.

2. Whenever, in the last section, any simple combustible body was particularly to be treated, care was taken, in describing the phenomena of its combustion, to announce the result, or the product which is always much heavier than the first body, because oxygen has been added. To designate this product, the terms oxides and acids have been used, and, as these two names only have been used in exhibiting all the results of the combustion of simple bodies hitherto treated, we have, in effect asserted, in other terms, that all the compounds of combustibles and oxygen, are either oxides or acids; and, in truth, when we consider the whole of the inflammable matters, presented by Nature in their burned state, we invariably discover either oxides or acids.

3. The general term oxide, is applied to such oxygenated bodies as are not acids, that is to say, which have not an acid taste, a strong attraction, and the other characteristic properties of this class of beings. Modern chemistry, by designating these oxygenated bodies under the name of oxides, has intended to show that these compounds have, nevertheless, analogies more or less marked with the acids; and that we may even consider them as such, as they have

the same habitudes in various combinations, and are subject to the same kind of attractions. These facts are expressed by the etymologic origin of this word, and its termination which resembles that of the acids.

4. We may distinguish two genera of oxides, or oxygenated bodies, which are not acid. The one, in fact, remain always such, and never pass to the state of acidity: in whatever manner they may be treated, they are not acidifiable. The other are only a kind of intermediate passage, between the state of a combustible body and that of acidity. They are oxides only, because they yet contain too small a proportion of oxygen to become acids. They are capable of acidification, if oxygen be added to them.

5. Among the oxides, properly so called, which cannot pass to the state of acids, we must reckon the oxide of hydrogen; or water, and a considerable number of metallic oxides. In the genus of those which can be acidified by an addition of oxygen, we reckon several combustible bodies, which are not metallic, and which being, in fact, capable of passing to the state of acidity, by a sufficient proportion of oxygen, they remain oxides only, until they have absorbed that proportion of the acidifying principle. Such particularly are phosphorus, sulphur, azote, and, perhaps, even carbon.

6. The oxides, whether non-acidifiable, or acidifiable, may also be distinguished by the various

rious proportions of oxygen, which each of the oxidable radicals, compared with each other, are capable of absorbing, and also by that portion of this principle, which each of them in particular can contain; that is to say, in other terms, each oxide of the same substance, varies in the quantity of oxygen it contains, and must also vary in its properties. This distinction will be found very necessary with regard to the oxides of each metal which differ much from each other, according to their greater or less advancement in oxidation. A number of chemical phenomena, formerly inexplicable, become very easily accounted for by this distinction which is directly proved by a number of experiments.

7. We may, likewise, distinguish the various oxides from each other, by the adherence of their principles. Some are decomposed, or dis-oxidized very easily. The simple contact of light is often sufficient to unburn these bodies; others, somewhat more difficult to be decomposed, require the addition of a greater or less quantity of caloric to the light; some are so permanent in their state of oxides, or retain the oxygen which is united to them with so much force, that it can scarcely be taken from them by any means, and, it is necessary to employ various means, at the same time, and several united attractions to arrive at this object. We must not forget that hydrogen and carbon, being the two combustible bodies which have the strongest attraction for oxygen, are almost always used
with

with success, though, in truth, with the assistance of a more or less elevated temperature to decompose the oxides.

8. I intend to speak, in two separate articles, of those three genera of principal oxides: that of hydrogen, or water, will hold the first rank, and form the first article. In the second, I shall place the metallic oxides, and the oxides of combustible bodies which are not metallic. Though the first only of these three kinds of oxides require to be treated at length, because the two following will be described in other articles, or sections of this work, yet it will be indispensably necessary to give some general notions on the metallic, and those not metallic, in order to present a perfectly methodical and complete system of chemical information; and to explain, in all its departments, the extensive course, which will remain to be passed through after their investigation.

ARTICLE II.

Of Water, or the Oxide of Hydrogen.

1. THE human mind, having been so long accustomed to class water among the number of the elements, seems averse to ranking it amongst compound bodies. This point, however, has been decided by experiment upwards
of

of fifteen years since; and, as it has not been opposed by a single fact, notwithstanding any hypothesis that may have been formed for the purpose of explaining the result, it is very evident, that if fifteen parts of hydrogen gas, absorb, in the act of combustion, eighty-five parts of oxygen, and if those two bodies form, by their union, one hundred parts of very pure water, when those gases are themselves pure, we may naturally conclude, that water is actually a compound of hydrogen and oxygen, each of which is separated from its gaseous solvent, and that it is a true oxide, because it does not possess the acid properties.

2. This kind of oxide of hydrogen, water, being diffused so abundantly over the surface of the globe, and in the atmosphere, under the forms, or in the states of solid, liquid, or elastic fluid, it is not a matter of surprise that many philosophers, on considering its great extent, its important uses, and its numerous phenomena, have considered it as an element serving for the composition and formation of many natural beings.

3. Chemists themselves must have adopted this opinion, in consequence of having observed water to result from most of their analyses, to present itself in an immense number of operations, and to be disengaged at the instant when the power, which united the principles of bodies, became relaxed, or broken by their operations. Obligated, in some degree, to consider it

as a common principle in a great number of compounds, they, for a long time, placed it among their chemical elements, under the name *phlegm*.

4. Though water is frequently afforded by Nature, in its three states, namely, solid, fluid, and vaporous, yet as each of these states depends on the different proportion of caloric, and would lead us to the history of its combinations, when a knowledge of the physical properties of water were to be communicated, before we can have considered its chemical properties, it appears very natural, that we should first consider it in its liquid state, because, in this state, its name of water is more particularly applicable, and, under this form, it presents itself most frequently, and in the greatest abundance to our observation, and produces the most numerous phenomena.

5. The naturalist, however, who must observe water in all its states, if he would acquire a knowledge of it in general, and comprehend its whole influence, describes it in the atmosphere under the form of clouds, and mists, precipitated from the air, in dew, rain, snow, and hail; collected on the surface of the earth, and producing rivulets, springs, torrents, rivers great and small, ponds, lakes, and seas, and on high mountains, as well as beneath the poles, in a state of eternal congelation. By making a distinction between the waters of the atmosphere, and those of the earth, he observes their transfor-
tion

tion from the surface of the seas to the atmosphere, their conveyance, by the winds, from place to place, in the midst of the atmosphere; he observes them, excavating, and forming ravines on the surface of the globe, filtrating through its strata, collecting in its subterraneous cavities, and forming capacious reservoirs, whence originate springs, and sometimes even rivers; he observes this fluid, gradually displacing the exterior masses, and the strata of the earth; wearing down and diminishing the mountains, filling vallies, forming extensive depositions at the bottom of the seas, which, after the lapse of ages, are found in a dry state, dissolving, and causing the crystallization of numerous fossils, incessantly changing their places, and filtrating in the vessels of vegetables; in a word, he observes, that water in a mass, in motion, and as a solvent, is one of the great agents of Nature, and acts in a thousand different ways on its phenomena. The whole of these details, which belong to the natural history of water, properly constitute the science of hidrology.

6. The natural philosopher, who most frequently observes the sensible properties of water in its liquid state, has determined its specific gravity to be eight hundred and fifty times greater than that of air; its perfect limpidity, its want of taste and smell; its incompressibility; its constant tendency to find its own level, which serves to determine the plain of the horizon, and leads us to a knowledge of the respective

spective position of bodies ; its pressure and density, in consequence of which sounds, or even light, are transmitted through it with much more difficulty than through air ; its accelerated motion of descent, by the inclination of the plane over which it flows, from which, as a first power, the mechanical arts are so highly benefited ; the communication of this motion to the bodies with which it comes in contact, or those which float, or are conveyed by its course, &c. ; by applying calculation to all these properties, we establish the principles of hydrostatics and hydrodynamics.

7. If we particularly consider its two states of solidity and elastic fluidity, it will appear, that ice is a perfect crystallization of water ; when from the separation of caloric, it exhibits, at its formation, all the phenomena of those bodies which crystallize ; at this instant, heat is generated, which causes the thermometer to rise several degrees ; and this formation is also accelerated by the access of air and motion ; its bulk is augmented, in a certain proportion, like that of the salts in crystallization ; its form is regular, as well by the constant union of its crystals at angles of sixty, or one hundred and twenty degrees, or in each particular crystal which is a prism of four sides, terminated by dihedral summits. When once formed, ice is capable of being reduced to dust ; it can lose much caloric, is very elastic, and exerts a strong action upon the organs of animals, by rapidly depriving

priving them of caloric. The air which is often contained between its particles, renders it opaque, and lighter than water in a liquid state. On melting, it constantly remains at the temperature of zero, as long as there is any portion of solid matter, because, on becoming liquefied, it absorbs all the uncombined caloric.

8. When we observe water in the state of elastic fluidity, it is found to be perfectly transparent; it becomes visible, white, and clouded, when the caloric, which it holds in solution, is disengaged; its bulk, compared to that of liquid water, is in the proportion of 800 to 1: its elasticity and spring produce violent explosions, and other remarkable effects, when applied to the mechanical arts, as may be seen, for instance, in the steam engine. Water readily combines with a great number of bodies: it facilitates combustion in such a degree, that it has been supposed to be changed into air, or to perform the functions of that fluid. When it passes again to the liquid state, it causes the separation of some uncombined caloric, and raises the temperature of all the bodies in its vicinity. To this change may be attributed the phenomena of a great number of aqueous meteors, and the constant rise of temperature in the atmosphere, after the condensation of the vapours of water.

9. Water undergoes no sensible alteration from the effect of light; in the state of ice it strongly refracts it; in the liquid state, the refraction

fraction is more than proportioned to the density of the water; and it was in consequence of this phenomenon, that Newton imagined it to contain something of a combustible nature, and suspected, as we may affirm, the presence of hydrogen an hundred years before the fact was discovered. The vapour of water readily decomposes, or disperses the various rays of light; or, in other words, it communicates, by refraction, the various and proportionate motions which give rise to colours. The vapour of water introduced into the air of a glass globe, placed between the eye and a light, exhibits all the tints of the rainbow. Though we are not yet acquainted with the manner in which electricity acts in chemical phenomena, yet it is necessary to describe its certain effects. When a great number of electric sparks are conveyed through a small tube, filled with water, by means of a conductor with a metallic knob, the water is decomposed, and separated into hydrogen and oxygen gas, and when this decomposition is so far advanced that the two extremities become immersed in the mixture of these two gases, so that the spark explodes in them, these gases again, take fire, and form water. Hence, the action of electricity may be said to decompose water into its two elements which it separates in the form of gas, and also to re-combine those bases, in such a manner as again to compose the dense fluid.

10. The action of caloric upon water, in its different states, deserves the whole attention of the natural philosopher, and the chemist. The former considers its changes of state, the latter its true chemical combinations, and all the effects of solutions. It is, therefore, necessary to observe the effects of chemical action upon ice, upon water in a liquid state, and also upon its vapour. Ice, in order to become dissolved, absorbs a proportion of caloric, which would raise an equal weight of liquid water through seventy-five degrees; its capacity is, therefore, much greater than that of liquid water, because, without acquiring a single degree of temperature, it takes from the cause which melts it, as much heat as would produce an elevation of seventy-five degrees in an equal quantity of water. Hence, liquid water is a perfect combination of ice and caloric; it is a fusion, in every respect similar to those of all other bodies whatever. The portion of caloric in fluid water, can only be estimated above zero, or the point of congelation; that portion, which is contained by ice, cannot be appreciated. Hence, we may account for the numerous difficulties and uncertainties among philosophers, with regard to the real zero, or the quantity of caloric contained in water at the true 0 of the thermometer.

11. Liquid water, ice in a state of fusion, or water in its ordinary state, is dilated, and increased, in bulk by the introduction of caloric between its particles. Water gradually increases

creases by sensible heat, till it arrives at a certain point, specified in the thermometer of Reaumur by 80 degrees, which, in the centigrade thermometer, is divided into 100; and the degrees of the latter instrument are adopted in the present work. It then undergoes no farther change; but passes to the state of vapour: every new particle of caloric combines with the hot water, and dissolves it into gas. Hence, the temperature of boiling water affords a constant, or stationary point. This change into vapour, or elastic fluid is attended with bubbles in greater or less abundance, and various sizes, which rise through the liquor with a degree of agitation, and produce the ebullition of the water. In order to render this phenomenon perfectly intelligible, I am accustomed to observe, that the water causes an effervescence with itself; and, in fact, it is an elastic fluid which rises from the body of a liquid, and no other idea can be formed of effervescence. It is, if the expression may be allowed, a portion of water formerly in a gaseous state, which becomes insoluble in water heated to one hundred degrees, and consequently then escapes. The bubbles proceed from the bottom, because the caloric there enters the water, which is no longer capable of receiving it, without assuming the gaseous form. The weight and pressure of the air, as well as its more or less solvent state, has an influence upon the ebullition of water: it boils more readily, or at less than one hundred degrees, when the operation

operation is made on a mountain, where the barometer does not stand at twenty-eight inches of the ancient French scale ; it boils with greater difficulty in cavities of the earth, where the mercury, in the barometer, stands at a greater height. It is, therefore, only at a given pressure of the atmosphere, that thermometers ought to be constructed ; and, for the same reason it is, that water, at fifty degrees, boils very rapidly in a vacuum.

12. The dilatation and ebullition of water by the introduction of caloric, does not, in the smallest degree, change the nature of this oxide of hydrogen. The vapour of water, or the aqueous gas produced by its ebullition, is not a permanent gas, but easily parts with the caloric it contains, and again becomes liquid by the contact of any cold body. On this phenomenon is founded the distillation of water; an operation which is very frequently performed in laboratories, for the purpose of obtaining this liquid in that pure state which is necessary for delicate experiments. For this operation, a tinned copper alembic, or still, is made use of: the water, which is placed in the kind of boiler called the cucurbit, or body of the still, ascends in vapour, by the action of the fire, into the head with which the vessel is covered. This being surrounded by a copper vessel filled with cold water, the low temperature of which condenses the vapour, the pure and liquefied water flows down into a gutter, or groove, in which
the

the head terminates at bottom, and which, by means of a slight declivity, permits the water to run off through a pipe, or beak, into a glass vase called a receiver. We might, also, avail ourselves of the natural distillation which takes place in the atmosphere, by collecting rain-water in the middle of an extensive yard, without receiving what falls from the roofs of houses, to obtain this fluid in a considerable state of purity. The ancient chemists even gave the preference to rain-water, for their experiments; and, it will shortly appear, that it differs from water artificially distilled, in consequence of the air with which it is impregnated, which air is not contained in distilled water.

13. Oxygen does not possess any very sensible attraction for water which is saturated with it. It cannot effectually combine with more than the proportion of 0,85 that it contains. Oxygen gas is, nevertheless, capable of becoming fixed, or being absorbed by water; and it is a fact well-known, and even proved, that water absorbs this gas in greater abundance, and with more facility than it does azote.

14. Water and air have a considerable attraction for each other: when air is passed through water, a quantity of the former is dissolved, which is more in proportion to the smaller portion of air, originally suspended in that fluid. Air which remains on the surface of water, or moves with rapidity on its surface, or still preferably, that which is agitated, and mixed with
water,

water, absorbs a quantity of this fluid according to its density . It is known that air, which is condensed, dissolves a larger proportion (of water), and, according as it becomes rarefied, the water is precipitated ; this will account for the slight vapour, or cloud, which is perceived on causing the receiver of an air pump to be exhausted. The solubility of water in air is, likewise, the cause of the evaporation which that liquid undergoes in the atmosphere. This evaporation is accelerated, or retarded by various circumstances, such as its temperature, pressure, &c. By the continual effects of solution and precipitation of water in atmospheric air, of which only the commencement of change are shown by the hygrometer, all the aqueous meteors are produced. It is necessary to make a proper distinction between the hygrometric state of the air, and the perfect chemical solution of water. Water, which is dissolved, can only be discovered by chemical processes, which will be hereafter explained ; but the hygrometer only indicates the solution and precipitation of water, at the instant when this solution and precipitation are effected. The air of a fine summer's day, apparently warm and dry, in which no humidity is manifested by the hygrometer, deposits water when immersed in ice ; and it is only at the time when this water becomes disengaged, that the hygrometer announces its presence. Though every circumstance which relates to the solubility of water in atmospheric air has been in-

finitely better appreciated in the modern philosophy, it, nevertheless, forms a part of meteorologic chemistry, which is yet in its infancy. It is of importance to be observed, in this place, that water agitated, or thrown into the air, besides dissolving and saturating it, may not only purify it by agitation and renewal, but also by carrying off the elastic, non-respirable and soluble fluids which it may contain, and are foreign to its proper nature.

15. As water is dissolved in air, air is, likewise, absorbed by water. Every time those two bodies are brought into contact, an equilibrium takes place, as in all other solutions. In proportion as the air becomes saturated with water, which becomes gazed, the water is saturated with air which adopts the liquid state. All water, on being exposed to the air, becomes impregnated with that fluid in greater or less abundance. This is one of the principal causes of the difference between the waters which flow on the surface of the earth, and those which filtrate between its strata, or remain, and stagnate in its cavities. This is also the chief difference existing between water, precipitated from the atmosphere during rain, and that purified by chemical distillation. Besides the various means possessed by chemists, for discovering the quantity of air contained in water, which will be mentioned hereafter; besides the well-known experiment of the bubbles of air disengaged from water, at the surface of which a vacuum

is made, air is observed to escape by the action of caloric in such a quantity as to produce an effect resembling the boiling of water. It is also seen to quit this liquid at the instant when it becomes congealed and crystallized. Hence, the solubility of air in water has, for its limits, the temperature of ice, and that of boiling water. On collecting air from water by the action of fire, it is found to be rather more pure than atmospheric air, and therefore, it is, concluded, that this liquid absorbs a greater quantity of oxygen gas, than of azote gas of the atmosphere. Water that has been perfectly deprived of its air, does not possess the lively and, as it were, pungent taste which it had before the time of such privation: it loads the stomach, and is not so favourable to digestion as in the other state.

16. No combination is known between water and azote. Azote gas, when brought into contact with this liquid, is not sensibly absorbed, and it appears to dissolve but a very small quantity of water. This negative property of azote gas, with regard to water, is also one of its characters which is frequently of advantage in chemistry, for discovering and distinguishing this kind of gas.

17. Hydrogen appears to have no attraction for water; the 0,15 parts of this principle, which it contains, completely saturate the oxygen, and hydrogen gas is not at all soluble in this liquid. Nevertheless, this gas often con-

tains a certain quantity of water, which it dissolves by passing through it. Water impregnated with air, and particularly with oxygen gas, appears to possess the property of absorbing hydrogen; but this fact, which has not yet been verified, seems to be owing to some degree of impurity in this gas, which varies considerably, according to the different combustible bodies which it holds in solution. We shall, however, soon see that azote and hydrogen, which alone are insoluble, become, on the contrary, very soluble, when they are combined.

18. Water has only a weak action upon carbon in the cold; it is easily absorbed by the different kinds of charcoal, which become humid in air, loaded with water, and exert upon it a kind of hygrometric action. I have examined pieces of charcoal, which had been preserved in tombs for several centuries, and found them softened, and rendered almost friable by the water with which they were impregnated. Nature possesses means, with which we are unacquainted, of dissolving carbon in water, for the purpose of conveying it into the organs of vegetables, of which it forms the principal nourishment. Though we can perceive no action between carbon in the cold, and water, yet a very strong action is seen between that fluid, and carbon in the ignited state. At this temperature, carbon has a greater attraction for oxygen, than hydrogen has for that fluid. The water is rapidly decomposed, carbonated hydrogen

hydrogen gas and carbonic acid gas are disengaged. Charcoal, completely ignited, and plunged under a receiver full of water, excites an effervescence, attended with a sensible noise, and produces the two gases above-mentioned. Hence, the reason, that on pouring a small quantity on a large mass of lighted charcoal, the combustion is increased, rather than extinguished; and also why humid charcoal, if strongly heated, burns with flame, and exhales an extremely fetid, and mephitic carbonated hydrogen gas. Water has but a small degree of action upon carbonated hydrogen gas: it, however, contracts a fetid odour by the contact, and dissolves a greater portion of this, than of pure hydrogen gas.

19. Phosphorus and water do not combine, either in heat or cold. We see phosphorus, under water, in a hot, liquid, and well fused state: by continuing the heat, it rises through the water, and burns at its surface, or is volatilized. Phosphorus may be preserved transparent without suffering any change, under boiling water that has been completely deprived of its air, by keeping the vessels which contain it well closed. On the contrary, aerated water gradually burns the surface of phosphorus, and covers it with a white oxide, which obscures its transparency. If phosphorus, immersed in aerated water, be exposed to light, the red colour, which it acquires, is a proof that it burns still more by the means of the oxygen which is dissolved

dissolved in the water. It is not ascertained, whether, at a very high temperature, phosphorus has not a greater attraction for oxygen than hydrogen has, so as to decompose water. This dangerous experiment has not been attempted. Phosphorus melted under water is easily inflamed, by bringing oxygen gas into contact with it at the bottom of the containing vessel; and this may be considered as one of the most brilliant combustions that can possibly be made.

Phosphorated hydrogen gas is not soluble in water. When kept, for a long time, in contact with this fluid, it becomes changed, ceases to be spontaneously inflammable with the air, and deposits a portion of phosphorus.

20. Sulphur and water in different states, and at any degree of temperature whatever, have no observable action. In the cold, sulphur, kept immersed in water, loses no part of its weight, nor does it communicate to it any particular chemical character; though some have pretended that it imparts some medicinal properties. When melted sulphur is poured into liquid water, particularly after it has been kept some time in fusion, till it has acquired a viscid appearance, it preserves a degree of softness, and ductility, which has already been mentioned in the tenth article of the preceding section: the water, however, though it acquires a slight taste, and a remarkable smell, does not produce any diminution in the weight of the sulphur. This
action

action ought not to be confounded with that of sulphur, when inflammation has commenced before it is immersed in water; in the latter case, a small quantity of sulphureous acid is dissolved. It is well known, that sulphur exerts no decomposing action upon water at an elevated temperature; that it, in no case, has a greater attraction for oxygen, than the latter has for hydrogen, and, for this reason, chemists have never been able to facilitate either the combustion of sulphur, or the formation of the sulphuric acid by water, even in a state of vapour. Sulphurated hydrogen gas is soluble in water, and forms an artificial sulphureous water. In the following section, we shall treat of this solution, when we speak of those bodies, from which sulphurated hydrogen gas can be most readily and abundantly obtained.

21. Water, though it does not dissolve sulphurated phosphorus, or phosphorated sulphur, nor is decomposed by phosphorus, or sulphur, appears, nevertheless, to be capable of decomposition by those two combustibles, when united in a binary combination. It has been observed, in the tenth article of the preceding section, that sulphurated phosphorus, melted in water, expands, and emits bubbles from its surface which frequently take fire in the air, at the same time that a fetid garlic smell is disengaged. These two phenomena prove, in fact, that water is decomposed, because there is a disengagement

ment of sulphurated and phosphorated hydrogen gas.

22. There is no action, whatever, between the diamond and water. It appears certain, however, that this combustible body, notwithstanding its extreme hardness, must have been dissolved in water, and that the constant and remarkable crystalline forms which it adopts in its natural state, can only be attributed to the gradual evaporation of its solvent, and to the concentration of its solution. By all the efforts of art, we have not hitherto been able to ascertain, nor even to imagine, by what process this solution can be effected in the bowels of the earth, where there is no doubt that it takes place.

23. Metals act in two general manners with liquid water, and water in a state of vapour; for their action upon ice is confined to a division of the caloric which each contains, according to their mutual capacity. Some, or rather most metals, have no action upon water, and remain in contact, without causing it to undergo any alteration, or being subject themselves to any change, whatever may be the temperature to which the mass is subjected. It has, however, been affirmed, that there is no metal which would not become oxidized in a state of extreme division, and with a very large quantity of water, by a violent and long-continued agitation; but it will be elsewhere shewn, that this effect can only depend upon the air contained in the water.

water. Some metals, namely, those which are the most combustible, and have the greatest attraction for oxygen, can decompose water, even when cold, though not with facility,—but rapidly, and in abundance, when their temperature is sufficiently elevated. In the latter case, a great quantity of hydrogen gas is disengaged, and the metal is reduced to an oxide. As this discharge of hydrogen gas takes place even in the cold, it appears, that the aqueous oxygen becomes more solid in the metal than it was in the water, and that the æriform fusion of the hydrogen is owing to the caloric which is separated. It will, hereafter, be seen, what a number of happy applications have been made to the science of this important fact, of the decomposition of water by metals, which was first discovered at Paris, in the year 1784.

24. Water, from its great abundance, its various states, its physical properties, and its chemical action upon a great number of bodies, whether, as a solvent, or by its decomposition, fulfils a number of functions in Nature and the arts. It would be almost superfluous, in this place, to give any exhibition of its important uses in the phenomena of Nature. The hydrographer, the geologist, the naturalist, the meteorologist—all are enabled, and ought to avail themselves of the information afforded by chemical science, to explain its manifold effects. Even the mechanic, though guided, in the use of this agent, by the laws of hydrostatics and hydro-

hidrodynamics, ought not to neglect the knowledge he may derive from chemistry, relative to this most important substance. This information is no less indispensable to the agriculturist, and the physician; for water performs a leading part as the food or aliment of plants, and animals, and as a remedy in the diseases of man and animals.—The mineralogist can acquire no certain ideas relative to the nature and difference of the waters of the earth, without possessing chemical knowledge. In short, the results of the chemical action of water, upon all the substances of Nature, and in all the productions of the arts, are so numerous, and of such utility, that each of the following articles of this work, will afford continual instances of the applications of water to every branch of natural philosophy.

ARTICLE III.

Of Oxides, Metallic and not Metallic.

1. IT is my intention, in this place, to speak of the metallic oxides, and the oxides afforded by several other combustibles, only in a general manner, in order to render the history of burned bodies, to which the present section is devoted, more complete, and methodically systematic. With respect to the oxides, some will be examined at length in the particular history of
of

of metals, which will form the subject of the sixth section of the present work; others have either been already noticed in the preceding section, or will be treated hereafter, with all the care and extent which the importance of some of them demands. The intention of this article, therefore, is only to afford a summary view of their Nature and differences, by considering them as forming a species of bodies, the Nature of which belongs to the series of compounds, which forms the subject of the present section.

2. The metallic oxides are produced by the combustion of metals; they are either natural or artificial, and seldom pure in the native state: it is to the art of chemistry that we are indebted for the preparation of most of those employed for various purposes, in the processes of the arts and manufactures. Most oxides are powders of various degrees of fineness, heavy, hard, and tinged with various colours, the most brilliant and durable in their nature, such as we admire in coloured glasses, enamels, and on China ware. Their taste is almost always rough, acrid, and caustic; some nevertheless, are almost insipid. Those, which, on account of their causticity, are ranked among the most violent poisons, owe their poisonous property to the oxygen, which adheres in a very weak degree, and is capable of being attracted by animal substances: those on the contrary, which are either insipid, or nearly so, retain the oxygen very strongly, and are not deprived of it but with difficulty.

3. They

3. They are prepared either with or without heat; by fusion of the metals, or without fusion; by the simple contact of air; by pure oxygen gas, or the decomposition of water: these effects are relative to the attraction which each several metal has for oxygen. This principle is contained in the oxides, in a more or less solid state, or more or less deprived of caloric: it is partly to this state of the oxygen that we may attribute the facility with which it separates from some, and the difficulty it meets with in separating from other oxides.

4. All the metals not only require each severally a different quantity of oxygen, to become saturated, but each particular metal, according to the manner in which it is treated, for the purpose of oxidation, absorbs different proportions of this principle. There are some which are found in four or five states of oxidation different from each other. We may therefore admit or imagine, in a metal which has attained its maximum of oxidation, different portions of oxygen, added, as it were, to each other; and as it is a law of chemical attraction, that the attraction acts in the inverse ratio of the saturation, it is evident that the first quantity of oxygen combined with a metal, adheres more firmly than the second, and the second more firmly than the third, so that the last which is added can be separated with more facility than any of the others. This essential distinction is a source of very important applications,

cations, by which we may account for, and explain a great number of chemical phenomena.

5. Light being moved in a different manner, and reflected with a particular motion from the surface of each metallic oxide, produces a change in each, according to its nature, and tends again to bring them to the metallic state, to reduce or unburn them. In this respect there are great differences between the various metallic oxides, according to the attraction exercised by oxygen upon the radicals, and the strength of its adherence. Hence the changes which metallic colours undergo, when exposed to the action of light in transparent vessels, and the necessity of keeping them in opaque vases, to preserve them from undergoing any alteration: the vitrified oxides, or those combined with glasses, either do not change at all, or are much less susceptible of alteration than the others, from the contact of light.

6. Caloric completely decomposes such metallic oxides as contain but a small portion of oxygen: from some it attracts only a part of their oxygen, which it converts into gas: on others it produces no effect, and there are some which it fuses into glass. If its action be assisted by light, its decomposing property is more effectual.

7. Oxygen produces no change in saturated oxides, but is often absorbed by those which contain only a small quantity of this substance.

The

The same effect takes place with the oxygen of the atmosphere. But we are acquainted with no action of azote upon the metallic oxides.

8. Hydrogen decomposes all those oxides, the metallic radicals of which do not decompose water; it frequently attracts the remaining portions of the oxygen, even from those whose metallic particles do decompose water. This effect takes place, either in the cold, or at a more or less elevated temperature. By this union of hydrogen with oxygen, water is formed, and the oxides resume the metallic state.

9. Carbon, at the temperature of ignition, decomposes all the metallic oxides; but it seldom produces any change in them without heat. It is by this substance that the oxides are most frequently reduced, and metals obtained. By the union of the carbon and oxygen in this process carbonic acid is generated.

10. Phosphorus decomposes several oxides in the cold, but still more with heat: it forms phosphoric acid, and also reduces the oxides, or brings them to a metallic state. Phosphorated hydrogen gas acts, in the same manner, on burned bodies, but more rapidly than phosphorus itself.

11. Sulphur decomposes but very few of the metallic oxides, or only deprives some of them of a portion of their oxygen; with others it combines perfectly, and forms sulphurated oxides. Sulphurated hydrogen gas acts quickly, and

and even at a cold temperature upon many oxides, by the double attraction of the hydrogen for part of the oxygen, and of the less oxidized metal for sulphur. It will, hereafter, be seen, that this action is the source of many very remarkable phenomena, and chemical combinations.

12. There is no action known to take place between the diamond and the metallic oxides. Some metals act upon several of the oxides, and decompose them, either completely, as is the case, when they have more attraction for oxygen than the radicals, or partially, by depriving them of a portion of this principle, and by becoming oxidized themselves, so as to remain with the former, in a sort of equilibrium of oxidation. This effect which takes place, in some cases, in the cold, and, at others, only by heat, affords many useful applications to the phenomena of chemistry, as will be seen hereafter. On passing from a metallic oxide into another metal, according to the laws of attraction, the oxygen, in its new combination, sometimes acquires a more solid state: a portion of caloric, and frequently even of light, is then disengaged, and the reduction of the primitive oxide, and the formation of the other is accompanied with inflammation. This effect is seen on the reduction of the red oxide of mercury, by zinc, tin, &c. a description of which I shall hereafter give.

13. Water

13. Water acts only, in a mechanical way, on a great number of metallic oxides, and serves to divide them, or to separate their particles, according to their degree of minuteness, as is done in many of the arts. There are some oxides which it dissolves, and which, in this property, approach to the nature of acids. Those susceptible of assuming the character of acidity, are also soluble, more or less, in water, like acids.

14. The metallic oxides act upon each other by means of caloric. Some are fused and vitrified by others; and, in this case, they frequently, by a kind of equilibrium of attraction, divide the oxygen in a different proportion from what it before existed in each. Hence, it is, that their colour, weight, hardness, and, in short, all their properties are changed in this act of combination.

15. Besides the metallic oxides, and the oxide of hydrogen, which have already been treated of, azote, phosphorus, and sulphur, when they begin to be burned, or when combined with a small portion of oxygen, afford to our observation those kinds of oxides which precede their conversion into acids. From this cause, according to the remark of M. Humboldt, it is, that phosphorus does not absorb all the oxygen of the air, but retains, in the azote gas which is saturated with it, a small portion of oxygen gas, and, by this means, constitutes a gaseous oxide of azote, and of phosphorus, or an azoturet of oxidized

oxidized phosphorus. With regard to the different oxides under their various forms, some have already been mentioned under the articles of the second section, in which they are treated. The oxide of azote will form the subject of a more particular investigation, when I shall treat of the nitric acid; for it must be admitted, that the nitrous gas, so often afforded by the partial decomposition of this acid, is a true oxide of azote. With respect to the oxides of phosphorus and sulphur, I have already observed, that phosphorus slowly burned by the aid of water, forms a white and crumbly dust, detached, and falling down from the solid and transparent phosphorus: this is the white oxide of phosphorus. When by strong, or rapid combustion, a portion remains in the form of a powder, or in red scales; this is the red oxide of phosphorus, nearly approaching to the acid state. The same effect takes place with sulphur: when it has been heated or melted, for some time, with the contact of air, it becomes red or brown, and is then in the state of oxide of sulphur. It does not admit of a doubt, that phosphorus and sulphur, in these oxidized states, must have properties of a different nature from those combustible bodies in the pure state, and that they deserve considerable attention from chemists.

16. It is very remarkable, that hydrogen can never be united to a state of oxidation less than that which forms water; and, as the water itself can no longer absorb a fresh portion of ox-

gen, we may conclude, that the two bodies, hydrogen, and oxygen, can only unite in a determinate proportion. The same effect was supposed to take place with carbon, of which the oxide was either not admitted, or unknown. But out of more than twenty-four combustible bodies, either acidifiable, or simply oxidable, there are only hydrogen and carbon, to which this conclusion is supposed to be applicable; for nothing is known, with certainty, as to the oxidation, or acidification of the diamond. We may, however, be permitted to believe, with several modern chemists, that carbon in a state of common and black charcoal is a kind of oxide of carbon: for it will be seen hereafter, that in many natural combinations, where it is not particularly oxidized, it has not a black colour, and that it adopts this colour only when it is insulated and has begun to be burned.

17. The last kind of oxides, of which I shall here say a few words, are those denominated *complicated oxides*, or oxides with *binary radicals*. These are ternary compounds of hydrogen, carbon, and oxygen; the last mentioned substance being united, at the same time, to the first and second, is not in sufficient quantity to saturate each individually: they are acidifiable by an accumulation of oxygen. They are found in vegetables, of which they represent, or constitute the immediate materials. In the seventh section of this work, they will be treated of at length.

18. From

18. From these general considerations it appears, that there are four very different kinds of oxides, which may be distinguished, and denominated as follows : 1. *Primitive binary oxides*, susceptible only of one proportion, and saturated in their principles from their first combination : in this class, there is only water, or the oxide of hydrogen. 2. *Variable binary oxides* : such are most of the metallic oxides, which may differ according to the proportion of oxygen they contain, or exist in different states of oxidation. 3. *Acidifiable binary oxides* ; or those which, by a new addition of oxygen, pass from the state of oxides, to that of acids : there are four metals, and phosphorus, sulphur, and azote, which admit of this change. 4. *Ternary oxides* : in this class, I comprehend carbonated hydrogen, or hydrogenated carbon, both oxygenated.

19. Lastly, if we consider the operations, or phenomena, by means of which the oxides and the acids are obtained, by burning, or uniting combustibles with oxygen, it will be seen, that this phenomenon may, in general, be comprised under the name of oxygenation, as a genus containing two species, namely, oxidation and acidification. These views will be developed in several of the following articles, which they will, at the same time, tend to elucidate.

ARTICLE IV.

Of Acids in general, and their Classification.

1. WE denominate acids, those burned or oxygenated bodies which are characterized by their sour taste, their property of reddening several blue vegetable colours, their strong attraction for most substances, and, by the formation of salts, when they are combined with the bases which will be treated in the following section.

2. Of all the acids, with which we are acquainted, the greatest number, when analyzed by different means, appear to be composed of combustible substances and oxygen. Many are, also, formed immediately by combustion; they may also be procured in a natural state, and may be obtained from the places where they are discovered, sometimes in a pure state; or otherwise, they may be separated by elective attraction, from the compounds which contain them.

3. As the intimate composition of most of the acids is known, and as they are constantly found to contain oxygen, their acidity is attributed to this principle, from which it has received its name from this effect. This doctrine is proved by three principal facts. Bodies become acid only by absorbing oxygen: and on depriving them of this principle, either totally,
or

or in part, their acidity is destroyed or diminished.

4. Since oxygen, or the acidifying principle, is common to all the acids, it is natural to attribute their generic acid properties to this principle, and the specific, or particular properties in each individual acid, to the body which is oxygenated by it, the effect of which must vary in each of its compounds. This is denominated the acidifiable body, the base, or radical. The last of these terms, which is now most generally employed, implies, that the acidifiable matter to which it is given, is, in some degree, the root of the properties which characterize each kind of acid.

5. Though the number of acids in nature, is very considerable, we shall here speak only of those which are formed by the simple or undecomposed substances examined in the preceding section. The distinction of mineral, vegetable, and animal acids, as formerly employed, will not be preserved, because it has produced many errors, and because they ought to be considered rather by their intimate nature than by their origin. It must, however, be observed, that those, which are here treated of, belong more properly to fossil than to organized bodies, being simple binary compounds, the radicals of which cannot be decomposed; whereas the acids, which are found in plants, are formed of binary radicals, and those of animals,

mals, often of ternary radicals, but always united with oxygen.

6. Carbon, phosphorus, sulphur, azote, and four metals, are the eight undecomposed combustible substances, which, when combined with a sufficient portion of oxygen, form the acids with simple or undecomposed radicals belonging to this section. There are also three acids which appear very analogous to, and equally simple with the preceding, and, like them, belong to the class of fossil, or mineral acids, though we have not yet been able to effect their decomposition; but they ought, nevertheless, to be placed in the same series. These are the muriatic, fluoric, and boracic: thus, by ranging them after the carbonic acid, of which carbon is the basis; the phosphoric acid which has phosphorus for its radical; the sulphuric which is formed by sulphur; the nitric, composed of azote; and the four metallic acids: the whole will amount to eleven acids, all of which are different from each other.

7. But as several radicals of these acids may be acidified in two states, accordingly as they have been more or less completely burned, or oxygenated, which has been already mentioned in the preceding section, we may add, to the above-mentioned eleven acids, the phosphoreous, sulphureous, nitrous, and one of the metallic acids, which will augment the whole number to fifteen. And as the muriatic acid may also be combined with oxygen, and pass to the particular

particular state of oxygenated muriatic acid, the total number to be treated of in this section amounts to sixteen.

8. It is almost superfluous to observe, in this place, that the two different terminations of the names applied to acids, explain the particular state of those compounds; those, for instance, terminating in *ous* are less charged with oxygen, than those which terminate in *ic*; that the specific names of the acids, are, in general, taken from those of their radicals; that though this rule has not been adopted, with respect to the nitric and nitrous acids, which having azote for their radical, and ought apparently to have been denominated *azotic* and *azotous*, it is because the authors of the nomenclature, not being satisfied with the first denomination, which they had but provisionally adopted, though it has remained for ten years, were, at the same time, inclined to respect the ancient names of *nitre* and *nitrous*, which were generally adopted.

9. All the acids contained in this section, have a sour taste; but in some this taste is so strong, as to render them caustic and terrible poisons; in others, it is in some degree moderated, while, in certain species, it is weak and never sour: in general, however, this taste, like all the acid properties, follows the inverse ratio of the adherence of the acidifying principle. The stronger the attraction of oxygen for the radical, the weaker is the taste, which shows us that the causticity is owing to the easy separation of this principle,

principle, and its more or less rapid transmission to animal substances.

10. The property of changing blue vegetable colours to red, which was formerly supposed to be an essential character of the acids, varies considerably, and is, at present, only a secondary character. There are several blue vegetables, which undergo but very little change by the action of these compounds; some acids redden only the most weak and delicate blues; others change the nature, injure, and even destroy this colour. But there are some which scarcely, in the smallest degree, or even not at all, affect the most delicate colours.

11. Some of the binary acids, or those with simple radicals, treated in this section, are decomposed by light; caloric volatilizes many, gasifies several, and fuses others, which are fixed in glasses. They have little or no action upon oxygen gas, if we except the acids terminating in *ous*, which have not been saturated, and absorb it gradually. Some attract the water dissolved in the atmosphere; others assume the state of vapour, and become dissolved; and others remain unchanged. Simple combustible bodies act very differently upon the acids: according to the force of attraction which exists between their radicals and oxygen, they are either decomposed, or not decomposed by some of those bodies, as may be seen in their individual history. Most of them are easily soluble in water: they all combine with most of the metallic

tallic oxides, and form salts that will be examined in the section on metals.

12. From the general differences which have just been stated, we may derive various methods of classing the acids. It will be first observed, that some are obtained by direct combination, and are decomposable, while the component parts of others continue still unknown as to their parts, as they have never been decomposed, nor can be artificially produced by combination. When considered with respect to their state of acidification, there are some which are weakly, and others strongly acidified. The names of the former terminate in *ous*, and those of the latter in *ic*.

Some acids can assume the form of gas, while others can only be obtained in the liquid state; some others are solid. The radicals of some are not metallic; others have metals for their bases. Several are reckoned among the most violent caustics, and some are but slightly acid.

But these distinctions can neither be indistinctly adopted, nor combined together; not only because this adoption would produce a very unequal division of the acids, but also because it would afford no real advantage. Besides which, since the sixteen species only of acids do not require any very considerable series of distinctive properties, when those acids, whose composition is known, are first treated, and afterwards the unknown, or undecomposed

posed acids, which, as I have already observed, have, nevertheless, too strong analogies to admit of their being separated from the former:—I shall only arrange the former, according to the degree of attraction which their radicals possess for oxygen, so that the first in order shall be the least, and the latter the most decomposable; and the latter, namely, those which are undecomposable, will be arranged according to their respective powers of attraction. After each acid saturated with oxygen, I shall place that which, though it has the same radical is less oxygenated, and is not so strongly acid as the first. From this simple classification, which possesses the advantage of continually presenting to the memory the most important chemical facts, namely, those of the elective attractions, I shall proceed to examine, under separate articles, the carbonic; the phosphoric; the phosphoreous; the sulphuric; the sulphureous; the nitric; the nitrous acids, and the metallic acids in general (which I shall here consider only as a genus of acids, because they will be examined at length in the section devoted to the particular history of metals); the muriatic; the oxygenated muriatic; the fluoric; and the boracic acids. Five metallic acids being thus comprised in a single article, there will be twelve articles required for treating of the sixteen acids.

ARTICLE V.

Of the Carbonic Acid.

1. THE carbonic acid, formed as has been seen, and as its name implies, by the saturated union of carbon and oxygen, the constant produce of the combustion of charcoal, which here possesses the first place in the order of acids, will always hold a distinguished rank among the discoveries of the eighteenth century, because it has led to a number of other discoveries which have produced the chemical revolution, and given birth to the pneumatic theory. It is necessary, therefore, to trace its history in a few words, because it is intimately connected with one of the greatest epochas in the history of chemistry, and because it is intimately connected with the advancement of the science.

2. The ancients considering it as a pestilential vapour, distinguished it by the name of *Spiritus Lethalis*. Paracelsus and Van Helmont conceived it to be a particular substance, and called it *Spiritus Sylvestris*, and gas. Hales, though he supposed it to be corrupted air, distinguished it by the appellation of fixed air, under which name it was known for a long time. Boerhaave obtained it by saline effervescence in a vacuum, and imagined it to be atmospheric air. Frederic

ric Hoffman discovered it in the acidulated mineral waters, and called it the acid vapour, and ethereal principle. Venel was the first who, in 1755, fixed it in pure water, and imitated a gaseous mineral water, by dissolving the elastic produce of an effervescence, though he attempted to prove that it was air.

In the year 1757, Black asserted that it is a peculiar substance, different from air; commonly saturating chalk and the alkalis, depriving them of their causticity: and he permitted it to retain the name of fixed air. Immediately after him, followed Cavendish, Macbride, Lane, Jacquin, Priestley, Bewley, Bergmann, Rouelle, and Chaulnes, who examined it with more or less attention, and discovered many of its properties and combinations, as well as its chemical attractions. After the result of their inquiries had been made known, it was generally considered as an acid.

In the year 1776, Lavoisier accurately determined its nature and composition, and asserted that it is formed of the pure part of charcoal and vital air, which truth had been discerned by Cavendish at least ten years previous to that period. It was lastly decomposed by Tennant and Pearson, who made an accurate analysis, and discovered that it contains the principles indicated by Lavoisier, viz. carbon and oxygen, and even in the same proportions which he had announced. The investigations of the above-mentioned chemists, during

during a space of twenty years, afforded more information relative to this acid, so long unknown to mankind, than was known with respect to the other acids which had been discovered several centuries before that period. These investigations also led to the study of the elastic fluids, and to the revolution that has taken place in chemistry.

3. From the numerous experiments made on this acid during the course of twenty years, it is not surprising that it should have received many different names. Such are, after those of *spiritus sylvestris*, or *lethalis*, the names of fixed or fixable air, which at first were generally adopted; afterwards those of *mephitic* acid, and *aërial* acid, the former given by Bewley, and the latter by Bergmann. The French for some time, adopted the denomination of Bucquet, who called it *cretaceous* (*craieux*) acid. Lavoisier, after having composed it in a direct way, distinguished it by the name of acid of charcoal, which at the epoch of the methodical nomenclature, in 1787, was changed to that of carbonic acid; and this denomination is at present generally adopted.

4. Though the most striking, and in some degree, the most characteristic state of the carbonic acid is that of elastic fluidity, it is not in this state that it is found most frequently and in the greatest abundance upon our globe. It is met with in the form of gas in many subterraneous caverns, in the Grotto del Cano,
near

near Naples, and generally in those countries which were formerly, or are at present subject to volcanic eruptions: it exists in a gaseous state in the air of the atmosphere, but combined only in the proportion of one or two parts in an hundred; many of the natural waters hold it in solution: in short it forms a constituent part of a number of salts and minerals, in which it is contained in a solid form; whence we may conclude, that Nature presents it in the three states of gas, liquid and solid. In this respect, it appears to be the most abundantly diffused of any acid: and if any of them could deserve such an appellation, the carbonic ought in preference to be denominated the *universal* acid.

5. Notwithstanding the abundance in which the carbonic acid is afforded by Nature, as it is seldom pure and at the disposal of chemists in its state of gas, it is obtained artificially in this state, by a number of different processes. Those processes are reduced to two classes; carbonic acid gas is either formed by direct combination, by burning charcoal in oxygen gas, by decomposing the metallic oxides, &c. by means of charcoal, assisted by heat, in the pneumato-chemical apparatus; by accelerating the spontaneous decomposition of saccharine vegetable substances, by the vinous fermentation, or by distilling at a strong heat, most of those substances, in the residuum of which the carbonic acid gas is found in abundance; or else

else this acid gas is extracted from the saline compounds, of which it forms a part, either by heating those compounds in luted vessels, or by causing it to be disengaged by means of acids stronger than itself. Among those processes the latter is generally preferred on account of its simplicity, its facility of operation, and of the small expence it requires. We shall speak of this process more at length, under the article of Salts; and it will therefore only be necessary to observe here, that as in most compounds, the carbonic acid is solid, it is a necessary condition, that at the instant of its separation, it should find a portion of caloric disengaged, to convert it into an elastic fluid.

6. Carbonic acid gas, whether taken from the subterraneous caverns, where it abounds, or extracted from the substances which contain it, is, as may be readily conceived, a combination of oxygen and carbon, fused in caloric, or a kind of ternary compound. To preserve its elastic fluidity, a great quantity of caloric is not necessary, because that which held the oxygen in solution, is partly disengaged during the solution of ignited carbon in that gas. This aëriform acid, which chemists have so long confounded with air, differs considerably from that fluid in all its properties. Though very transparent, and in most instances equally invisible as air, it is often rendered visible and vaporous by water, which it holds in solution, as well as by smoke, which, remaining at its surface, and supported

supported by reason of its greater density, forms a stratum between it and the atmosphere. It is nearly double the weight of common air, so that it may be poured from one vessel into another, where it displaces the air, and remains in vessels opened at the top, in cavities of the earth, and may be made to flow from cocks, in the same manner as a liquid. When poured in the sunshine, into a vessel full of air, its density being greater than that of water, cause it to become slightly visible by the undulations and veins which it forms on passing through this fluid. It is not fit either for combustion or respiration. It stupefies and speedily kills animals, depriving the heart and muscles of all irritability, so that they are no longer affected by the Galvanic power. It extinguishes lighted bodies in the same manner as if they were plunged into water.

7. It has a particularly pungent smell, which may be perceived above the vessels in which wine or beer is in a state of fermentation: it is also exhibited in lively Champagne wine. When an operator wishes to discover its presence, by holding his nostrils over a vessel in which it is contained, he should be careful not to breathe it incautiously; because it excites cough and sneezing, and produces such a degree of giddiness and weakness as may occasion fainting. This gas is also found to possess a taste rather acid and pungent: it easily reddens the tincture of turnsol, which when exposed to the

the air, resumes its blue colour in proportion as it is deprived of this acid, which is gradually attracted by the air of the atmosphere.

8. Carbonic acid gas admits the passage of light, and refracts it without undergoing any sensible alteration; it will be seen, however, in the sequel, that it tends to decompose it, and favours the separation of its principles by other bodies. Caloric dilates this gas in a proportion, which, when compared to the susceptibility of dilation possessed by other elastic fluids, has not yet been determined. Carbonic acid, whether liquid or solid, has such a tendency for fusion in caloric, and so great a disposition to become gaseous, that it is separated by fire from most of the compounds which contain it, and is thus disengaged in the form of an elastic fluid.

9. There is no known action between carbonic acid gas and oxygen. It cannot absorb a greater quantity than it contains, or become super-oxygenated. When this acid gas is mixed with oxygen, it may be respired, provided the former does not exist in a greater proportion than one third of the latter, for then it acts upon the lungs, and injures the individual by whom it is respired. Carbonic acid gas, when left in contact with air, is gradually dissolved; and the more this contact is increased, the more perceptible is the solution. In a large and open vessel the carbonic acid gas is quickly dissipated; in a long narrow vessel, the orifice of

which is closed, it remains a much greater length of time before it is dissolved in the air. It has been already observed that the air of the atmosphere always contains a portion of this gas, equal to 0,01 or 0,02. It may be increased to 0,10, and inspired without danger by patients who have symptoms of ulceration or inflammation of the lungs, which it is known either to cure, or to retard their destructive effects. If this gas, mixed with air, remains at rest, in a dose exceeding a few hundredth parts, it precipitates and occupies the lower part of the vessel.

10. We are not acquainted with any attraction between azote and carbonic acid. Carbon having a much greater attraction for oxygen than is possessed by azote, the latter produces no change in carbonic acid. On mingling carbonic acid gas with azote gas, the former being yet more dense in comparison to the latter than it is with respect to the air, is separated more rapidly, and subsides towards the bottom of the vessels in which the mixture is made.

11. Though the attraction of hydrogen for oxygen, at a cold temperature, is greater than that of carbon, since the latter, as has been shown, decomposes water only at the temperature of ignition, yet hydrogen gas has no action upon carbonic acid gas at any temperature. Those elastic fluids, when mixed, separate according to their specific gravity; this effect, doubtless arises from their gaseous state; for
every

every circumstance announces that hydrogen, either in a liquid or solid form, must be capable of decomposing carbonic acid in the same state. Though no proof of this fact has yet been obtained, it nevertheless probably takes place in the animal and vegetable compounds: we shall resume this important topic in the seventh and eighth sections of the present work.

12. There is no known attraction or chemical combination between carbon and the carbonic acid; which cannot absorb a greater quantity of this principle than it contains. We have, however, been told of a carbonous acid, that is to say, the carbonic acid loaded with carbon. In the course of the present work, it will be seen that the vegetable acid matter, the acid of nut-galls, in which this combination has been ascertained to exist, cannot be considered as such, because it at the same time contains hydrogen, which is essential to its nature, as a ternary compound. Heated charcoal has the property of absorbing and condensing carbonic acid gas between its pores; the latter, however, adheres but slightly, and an immersion for a few seconds under water, is sufficient to effect its separation, either by dissolving or disengaging it.

13. Phosphorus has no action upon the carbonic acid; it does not dissolve in this gaseous acid at any temperature whatever; it does not change its nature; because the attraction of carbon for oxygen at the red heat is greater

than that of phosphorus for the same body. It will, however, be seen hereafter, that by means of a disposing attraction, the carbonic acid may be decomposed by phosphorus.

14. Sulphur, being still less attracted by oxygen than phosphorus, and consequently much less than carbon, does not act upon carbonic acid in any manner, nor at any temperature. It has been asserted that it is partly dissolved by heat, in this gaseous acid, and that it in some degree imparts the fetid odour of sulphurated hydrogen gas; the same effect must take place with phosphorus; but these slight and transient solutions are momentary suspensions, and not real combinations.

15. The hydrogenated, carbonated, phosphorated, and sulphurated gases do not act upon carbonic acid in any manner that can be perceived or estimated. By a mixture of the last-mentioned with the former gases, however, their inflammability is diminished or entirely prevented. We meet with similar mixtures in several analyses, particularly in the products of the decomposition of animal and vegetable substances. The inflammable gas generated in marshes, is often that of carbonated hydrogen, intimately mixed with carbonic acid gas. The sulphurated hydrogen gas obtained from sulphureous springs, is also frequently mixed with carbonic acid gas.

16. The carbonic acid does not act upon the diamond; it can have no other relation than
what

what results from the natural analogy that appears to exist between the pure adamantine substance, and the radical carbon of this acid.

17. Most metals undergo no alteration by the contact of the carbonic acid; some of those which have the greatest attraction for oxygen, become much more capable of decomposing water, and depriving it of its oxidizing principle, when the carbonic acid is at the same time in contact with the metals and water; a proportion of hydrogen gas being then disengaged. This effect takes place in consequence of the disposing attraction which exists between the acid and the metallic oxides. Hence it may be observed, that there is no union between the metals and carbonic acid, and that it commences only at the instant when the oxidation of the former takes place. It appears, however, that iron, like phosphorous, is capable of decomposing the carbonic acid, united to a base, and to this is owing the important fabrication of cast steel, by igniting iron with marble, and the earth of crucibles, according to the discovery of Citizen Clouet. This subject will be treated under the article Iron.

18. There is a considerable attraction between water and carbonic acid gas. On leaving this gas in contact with water, the latter gradually absorbs it, and causes it entirely to disappear. When liquid cold water is agitated
with

with carbonic acid gas, the combination takes place with much greater rapidity. It is generally said that the water dissolves the gas; but this is an erroneous expression, since the term to dissolve can only be applied to a solid body which melts in a liquid. It is proper to observe that the water condenses and liquefies the carbonic acid gas by absorbing it. This absorption cannot take place, unless the gas loses its elastic fluid form, and becomes diminished considerably in bulk: in this case then, it parts with its æriform solvent, or caloric: but it contains such a small quantity, that the separation is not perceptible, and is effected without producing heat. Nevertheless when ice is immersed in this gas, it loses its solidity, and becomes fused at its surface.

As the combination of carbonic acid gas with liquid water, is one of the most important phenomena of this acid; and as it at the same time affords one of the most useful articles of the materia medica, it deserves to be carefully described.

Though water, at the temperature of fifty degrees, and still more when at the boiling point, does not absorb the carbonic acid gas, which passes through it without loss, and even increases in bulk;—though it has been justly said, that the colder liquid water is, the more of this gas it will absorb, it must nevertheless be remarked that this absorption at low temperatures has a fixed term. At 0, or at the freezing point, no union takes place between these

these two bodies: hence the reason why water containing carbonic acid gas, discharges or loses it at the instant of freezing; but above 0, it is ascertained that liquid water absorbs the gas in a greater quantity, the nearer it approaches to that degree. At twelve degrees, the common heat of the most temperate climates, which is universally called the mean temperature, water retains $\frac{1}{542}$ of its weight, or nearly its own bulk of carbonic acid gas; at two or three degrees above 0, it may retain nearly double the quantity. By adding pressure to the cooling, the absorption of this gas by water is singularly facilitated. With the assistance of machines, for the purpose of effecting this pressure, the philosophers at Geneva have been enabled to condense in a portion of cold water, more than twice and an half its bulk of carbonic acid gas, and thus to form artificial gaseous waters considerably stronger, and much more impregnated than those afforded by Nature.

Several machines of different constructions have been invented, in order to effect this absorption, or to saturate water with carbonic acid gas. Simple agitators, which mix and divide it in the vessels immersed in an atmosphere of this gas, such for instance as the top of a cask containing wine or beer in a state of fermentation, will be sufficient for this purpose. A large cask, filled with equal bulks of water, and carbonic acid, which are agitated and
mixed

mixed together by rolling on an axis (in the same manner as is practised in making comfits) is a very convenient apparatus, because this proportion of absorption is sufficient for every purpose; and though this water is denominated *acidulous*, *spirituous*, *gaseous*, &c. the name of carbonic acid, which expresses its liquid state, is more proper for distinguishing this combination.

19. The carbonic acid in a liquid state, or solution of carbonic acid gas in water, as it is generally denominated, is heavier than pure water; its proportion to the latter is as 10015 to 10000. It has a pungent sharp acidulous taste; it effervesces on agitation, and emits a number of bubbles. It often expels the corks, or breaks the bottles in which it is contained: it is deprived of its acid gas by the exhaustion of the superincumbent air in the pneumatic machine,—by simply exposing it to the air, which gradually dissolves it,—or by caloric which may be applied or accumulated in it. In the latter case it appears to boil much more quickly than common water. It reddens the tincture of turnsol. It is preserved by keeping it in well-stopped vessels, by compressing it forcibly with corks confined by strong pack-thread or wire, and storing it in places below the temperature of 12 degrees.

20. The discovery of this solution or liquefaction of carbonic acid gas in water, has explained the nature, properties, and formation of

the mineral waters denominated acidulous, spirituous, or gaseous; it has been found that the latter are absolutely the same as those prepared by chemical processes, and hence they may with great precision, be imitated by art. This important discovery, besides affording numerous applications relative to the history of salts, of which we shall speak in the following sections, has also explained the cause which produces the pungency and other similar properties of beer, cider, and new wines. It is nothing more than a disengagement of the carbonic acid, which has been confined during the vinous fermentation.

21. Most of the metallic oxides are capable of uniting with the carbonic acid, and thus forming saturated compounds, which are often afforded by Nature in great abundance, and may be easily prepared by art. Some oxides even have the property of absorbing this gaseous body, when heated and immersed in it. In a liquid form it also combines with them, and renders many of them soluble in water. This phenomenon, by explaining the formation of several minerals, and of certain mineral waters, has greatly contributed to the advancement of mineralogy, as I shall hereafter shew. It will be easily conceived that the accounts relating to the union of the carbonic acid with the oxides, and the nature of the metallic carbonates, most properly belong to the particular history of metals.

22. What

22. What has been explained here with respect the properties of the carbonic acid, is sufficient to show how much light has been thrown on the phenomena of Nature and the Arts, by the discoveries relative to this acid. The combustion of charcoal, the alteration it produces in the air, the noxious effects of subterraneous caverns, the formation of salts, minerals, and mineral waters, the production of this acid, and of water, in respiration, which partly consists in the oxygenation of the superabundant carbon of the blood; even vegetation itself, as I shall prove in a subsequent section, and a number of other phenomena, which will be developed in the following articles, and were formerly considered as inexplicable miracles; have all now become simple questions of easy solution. Hence we see how considerable an addition the science of natural philosophy has received from the experiments made with the carbonic acid.

23. The whole history of this important acid may be divided into six principal heads; viz. that of

A. Its intimate composition by the union of 0,28 of carbon, and 0,72 of oxygen, together with a certain quantity of caloric, by which this binary compound is held in gaseous solution. It takes place in a number of circumstances, which have either been already mentioned, or will be spoken of hereafter, and which renders very intelligible.

B. Its

B. Its natural history, which presents it in a pure and gaseous form, or in gas combined with the atmospheric air, or in a liquid state combined with water, in that of solid and salifying or mineralizing a number of fossils.

C. Its physical properties, when in the state of gas; its specific gravity, taste, and smell, compressibility, dilatability, &c.

D. Its combinations, into which it totally enters, and of which it forms an integrant part. These will be considered at length in the following sections.

E. Its decompositions which take place only by complicated and pre-disposing attractions, and will be spoken of several times in some of the articles of the fifth section.

F. Lastly, its multiplied applications to the phenomena of Nature and Art, which present the knowledge acquired under the five preceding titles, and the uses to which it may be applied.

24. These uses of carbonic acid gas, or of the carbonic liquid acid, are very frequent in chemistry, and serve for the preparation of several compounds, or in the demonstration of scientific truths. It is also used on many occasions in medicine, as a bracing, antiseptic, diuretic, antiscorbutic, anticancerous remedy, &c. It has even been extolled as almost a specific in the stone of the bladder. But though it is not a remedy to be neglected, it has been very far from answering the
the

the sanguine expectations that had been formed of it. One of the cases in which it is most effectual is that of the hemorrhoids, the pain of which it frequently alluages, at the same time that it appeases and diminishes the swelling and distension.

ARTICLE VI.

Of the Phosphoric Acid.

1. THE name of phosphoric acid is sufficiently comprehensive, according to the rules laid down in the fourth article, to denote the saturated acid combination of phosphorus and oxygen. I place it the second in the order of acids, with simple radicals, because its radical holds this rank among the combustible bodies capable of acidification, in consequence of its attraction for oxygen. It is placed immediately after carbon, and has never been known by any other appellation.

It has sometimes, however, been called the acid of phosphorus; but this denomination is improper, because it appears to denote its being derived from phosphorus, which is an error of the ancient system of chemistry, and also because if we understand it to imply an acid prepared with phosphorus, it will be confounded with another, namely, the phosphoreous acid, from which it ought to be carefully distinguished.

tinguished. In this latter point of view, the name of acid of phosphorus might be considered as generic, and thus it would, in a certain respect, have two species; one the phosphoric, and the other the phosphoreous acid.

2. The phosphoric acid has not long been known in chemistry. In conformity with the doctrine of Stahl, it was for more than one-third of the eighteenth century, supposed that phosphorus, then procured by a method which will be speedily described, was produced by the muriatic acid, hereafter to be treated of. Margraff was the first who, in the year 1743, accurately distinguished it from all the other acids, who proved that it exists in human urine, and that it is alone capable of affording phosphorus, and that phosphorus alone can be changed into phosphoric acid.

This important discovery was soon confirmed by the chemical world, and the error introduced by Stahl was unanimously rejected. The same acid was afterwards found in certain vegetable substances, though an opinion had long prevailed that it was almost entirely confined to animal matter. In the year 1772, Scheele and Gahn discovered it in bones, Bergmann, Proust, and Tenant extracted it, in considerable abundance, from several saline and metallic fossils. Lavoisier proved, by accurate and ingenious experiments, that it is formed of phosphorus and oxygen; and even ascertained the proportion of its constituent parts; and since that period, no
obscurity

obscurity has remained with regard to its properties.

3. Though we can no longer, at present, assert, that the phosphoric acid belongs to a particular class of natural bodies, as it is extracted from fossils, and even from a crystal gem, the chrysolite of commerce, as well as from vegetables, and animals, it is, nevertheless true, that it is very generally found diffused in animal substances, from which it may be easily extracted; that it is scarce, and not abundant in vegetable compounds, and that it is even more frequent in minerals than in them. It acts a very important part in natural phenomena, whether geodesial, or those relating to animalization.

4. Pure phosphoric acid is never found native. It is extracted by art from natural compounds, whether earthy or metallic, animal or fossil, by means of acids stronger than itself: it is composed in a direct way by the rapid combustion, or deflagration of phosphorus. As the first process frequently affords only an impure phosphoric acid, recourse is more commonly had to those of the second kind, or the complete fabrication, when this acid is required in a great degree of purity. For this purpose, phosphorus is burned under receivers, filled with oxygen gas, placed over mercury, the ignition being commenced by means of a curved rod of iron, which is made red-hot, and passed through the liquid metal. Another method of burning it, consists in fusing it under water,
and

and conveying oxygen gas to it, by means of a tube. In the first method, it is obtained in white, concrete, crystalline, and snowy flakes; in the latter, it is much diluted by the water, but may be concentrated by evaporation. It may, also, be formed by decomposing, by phosphorus, those acids the radicals of which have a less affinity for oxygen than this combustible body, as will be shown under the articles of those acids.

5. In all the preceding operations, it is necessary, in order to obtain phosphoric acid, to employ nearly two parts of oxygen to one of phosphorus; it is also found, that the oxygen gas loses, in this combustion, the greatest possible quantity of its solvent caloric; and that it must, therefore, be highly concentrated in this compound. This important result of modern experiments, explains a number of properties possessed by this acid, which were formerly unintelligible.

6. The phosphoric acid is generally kept in laboratories, in the form of a thick and almost viscid liquor, resembling certain oils, producing striæ on the vessels in which it is agitated; of a specific gravity more than double that of water, perfectly inodorous, of a very acrid, but not caustic taste, and never burns organic substances; it reddens a great number of blue vegetable colours, is quite incombustible, and possesses, in a remarkable degree, that property of attracting, and of being strongly attracted, which

which the genius of Newton had attributed to the acids. When it is produced immediately by combustion without moisture in oxygen gas, it adheres to the sides of the vessels, in which it was sublimed by heat, before its perfect combination, in the form of white, brilliant, crystallized, and very acrid scales, which soon lose this state, and pass to that of liquid, by the contact of the least humidity, or even of the external air. And lastly, it is often exhibited in the vitreous form of which we shall speak hereafter.

7. Light has no action upon the phosphoric acid, which strongly refracts it. When exposed in a liquid state to caloric, it becomes thick, concentrated and condensed, loses its water, which evaporates, and carries with it a very small portion of the acid. It may be brought to a state of transparent jelly, and preserves this form in a well-closed vessel, but again becomes liquid on being exposed to the air. Water is, therefore, much more volatile than this acid. If, when it has taken the gelatinous form, the heat be continued till it become ignited, it melts, expands, is covered with bubbles, and, at last, remains in a state of quiet fusion. Before the blow-pipe, in the platina spoon, or in the cavity of charcoal, it may also be made to adopt the form of a vitreous, and very transparent globule, similar to a gem of the finest water. In this vitreous state, the phosphoric acid being very brilliant, imitates the sparkling of certain precious

precious stones: it is always acid, deliquescent in the air, and soluble.

8. This singular vitreous state, of which the phosphoric acid is susceptible, does not, in any respect, alter either its nature, or the proportion of its constituent parts: it proves the great fixity of this acid: and if we are surprised to learn, that it contains a substance so volatile as phosphorus, we must recollect the state of solidity which the oxygen has acquired by losing so enormous a quantity of caloric. The vitreous phosphoric acid can only be obtained in a very pure state, when it is the product of phosphorus burned by oxygen; and when it is melted in a platina crucible. When it has been extracted from a compound, of which it formed a part, it often retains a small quantity of the earthy, alkaline, or even metallic bases to which it was united. When fused in vessels of earth, glass, or metal, it dissolves the material or substance of these vessels; it affords after fusion, opaque glasses, which are coloured, insipid, insoluble, not deliquescent in the air, but odorant, and luminous when rubbed in the dark. When a glass of very pure phosphoric acid is dissolved in water, it does not, in the least degree, differ from the phosphoric liquid from which it was produced.

9. It must be observed, that the concrete and lamellated phosphoric acid immediately melts into glass the instant it becomes ignited, without swelling, or affording bubbles; which is a consequence of its not parting with water, or

because it has little to lose before it assumes the vitreous state. This glass, when once formed, also melts without motion or vapour, as soon as it is red; it is even so fusible, that it may be used as a solvent for many other bodies.

10. The phosphoric acid, in its various states, has no attraction for oxygen, nor its gas, being completely saturated with that principle. By exposure to the air, it only attracts its humidity; that which is dry and concrete attracts moisture with great force and rapidity; whereas in that in the gelatinous, or dense liquid state, the attraction operates more slowly; but this also absorbs nearly half of its weight; the vitreous acid requires a length of time to become humid; and when its external stratum is thick and gelatinous, this defends its internal part, so that it long retains its form, and acquires the liquid state not without much difficulty. It undergoes no change from the action either of azote or azote gas, from which, as we shall hereafter explain, phosphorus absorbs oxygen.

11. No action is observed between the phosphoric acid and hydrogen gas: nor is there any absorption, or change, in either by contact. It has not been proved, by any direct experiment, that the phosphoric acid, in a state of fusion, is decomposed by hydrogen; it might be conjectured, that water and phosphorus are formed, though the attraction of hydrogen and phosphorus for oxygen, appears to be very nearly, or almost alike, from the small degree of
auxiliary

auxiliary or disposing force, which is required to be added to phosphorus, in order to decompose water.

12. Carbon does not, in any degree, alter the nature of phosphoric acid in the cold; so that, at a low temperature, phosphorus has a greater attraction for oxygen than for carbon; but in a heat, sufficient to ignite the latter, if it be brought into contact with the former in its dry or vitreous state, the order of attractions is reversed; the carbon absorbs the oxygen from the phosphorus, which, on being disengaged, rises in sublimation, at the same time that the carbonic acid which has been formed is driven off. Such is the theory of the operation by which phosphorus is obtained, when dry phosphoric acid is distilled with charcoal; an operation which has now become much more simple and easy than it formerly was. Though this experiment may succeed, by distilling a mixture of liquid phosphoric acid mixed with powdered charcoal; or else a mixture of charcoal, and six times its weight of vitreous phosphoric acid, both reduced to powder,—yet the first process requires a tedious first operation, and the latter too strong a heat, which often breaks the earthen retorts which are commonly used. The preference ought, therefore, to be given to the operation which consists in taking phosphoric acid of the consistence of honey before fusion, and distilling it in luted glass retorts, with a sixth part of its weight of charcoal of white wood.

Some water is placed in the receiver, in which the extremity of the mouth of the retort is immersed, in order that the hot and melted drops of phosphorus which are distilled, may not burn, but be quickly congealed in the water which receives them. A still better kind of receiver is a vessel of copper, about two-thirds full of water, having a tube, passing to the bottom of the vessel, to receive the neck of the retort. The decomposition of phosphoric acid by carbon, agrees, with its formation, in proving that it is composed of 0,39 of phosphorus, and 0,61 of oxygen.

13. Phosphorus cannot be combined in a direct manner, with the phosphoric acid, either with or without heat. Caloric, which so frequently assists the mutual action of bodies, does not produce any effect in the present instance; because the phosphorus is very volatile and fusible, and the phosphoric acid fixed, and long in assuming the vitreous and igneous state of fusion. Nevertheless, the phosphoric acid is apparently capable of combining with a greater quantity of phosphorus, so as to pass to the state of phosphoreous acid. But this order of acid combination, cannot take place except by uniting only a small quantity of oxygen to the phosphorus at the instant of combustion, and not by the direct addition of more phosphorus to the phosphoric acid.

14. Sulphur does not act, in any manner, upon the phosphoric acid, whatever may be the temperature

temperature at which they are treated. Phosphorus having a greater affinity to oxygen than sulphur has, can neither give to nor divide with the latter the oxygen with which it is saturated.

15. There is no action between phosphoric acid and the diamond. The latter remains amidst the acid, when in a state of fusion, and may be kept for a length of time red-hot, without experiencing the slightest alteration: this fact constitutes a difference between the diamond and carbon, in common with which, however, it appears to possess the remarkable property of affording carbonic acid by combustion. It may probably be attributed to the strong aggregation of the particles of the diamond.

16. No metal, in the metallic state, can unite with the phosphoric acid. This acid, in the liquid state, undergoes no alteration, whatever may be the temperature to which it is exposed along with the metals: but by the addition of this acid, several of the metals acquire the property of decomposing water, of disengaging its hydrogen in gas, and absorbing its oxygen. This effect is owing to a disposing attraction. When the most combustible metals are heated with the vitreous phosphoric acid, though none of them has, in reality, a greater attraction for oxygen than phosphorus has, there is, nevertheless, by means of a double attraction, a formation of oxide and metallic phosphuret. To obtain this kind of compound, it is necessary to
submit

submit to a strong heat in a crucible, three parts of metal with one part of concrete phosphoric acid; which will entirely disappear; and the metal will be found partly oxidized, and partly combined with the phosphorus. The following is the theory of this operation: the quantity of the metal being more considerable than would be necessary to absorb all the oxygen contained in the phosphoric acid, part of this metal acts upon the oxygen of the acid, while the other part acts upon the phosphorus, and hence results, both an oxide and a metallic phosphuret. This instance of double attraction on the part of a single body may be applied to several facts of the same nature.

17. Water has a great attraction for the phosphoric acid. When in the form of white and dry flakes, it dissolves in a small quantity of this fluid, causing a noise similar to that of red-hot iron, when plunged in water, and disengaging a quantity of caloric.—The vitreous acid is far less speedily dissolved; the concentrated liquid phosphoric acid slowly unites with it, and produces scarcely any heat. These two bodies may be combined in every proportion. The acid loses more of its taste, density, weight, and force, in proportion as the quantity of water is increased: and the water can only be separated from this combination by means of caloric. It is much more volatile than the acid, which becomes concentrated accordingly as the water is disengaged in the form of vapour. The acid,
after

after this evaporation, passes successively through the states of dense, viscid, gelatinous fluid, to that of glass.

18. The phosphoric acid readily combines with most of the metallic oxides, with which it forms salts fusible by heat; sparingly soluble in water, but soluble in the phosphoric acid; some of which are crystallizable by cold after fusion. Most of them, when heated with carbon, afford phosphorus, or metallic phosphurets. Each of these salts will be described under the articles of the metals.

19. The phosphoric acid does not form any combination with carbonic acid, nor its gas. As it is stronger, or more susceptible of change than the latter, by a great number of bodies, it expels the carbonic acid from most of its combinations: and thus separates it from water, and produces an effervescence in the acidulous waters, whether natural or artificial.

20. The accurate knowledge we possess, respecting the properties of the phosphoric acid, render it of importance at the present period in a great number of chemical operations. It is, therefore, to be regretted, that this acid is so scarce and dear, on account of the difficulty with which its radical is procured, for if it were more common, many advantages would be derived from it in the sciences. To the same cause, doubtless, may be attributed its present limited uses; for several of its saline combinations are scarcely known or employed; as will
be

be shown in some subsequent articles. Its principle use is for the extraction or preparation of phosphorus. Physicians have begun to prescribe it as an antiseptic, cooling, and solvent medicine; as an external application in several tumours, and particularly those of an osseous kind. It is particularly used in the preparation of salts which are given as opening medicines.

ARTICLE VII.

Of the Phosphoreous Acid.

1. THE phosphoreous acid has, even in modern times, been confounded with the phosphoric acid. It was not known, till the new ideas had been formed respecting the various degrees of combustion and the different proportions of oxygen united to combustible bodies, that phosphorus, when slowly burned, forms a kind of acid, different from that afforded by it when burned rapidly, and with deflagration. Lavoisier was the first who, in 1777, proved that the acid obtained by the perfect combustion of phosphorus, forms combinations very different from those afforded by the acid which is obtained by the slow combustion of the same substance.

2. The principles adopted in the new nomenclature show, that the phosphoreous acid is less strong, and less active than the phosphoric acid,
- and

and contains less oxygen; that it is constantly the produce of a slow and merely luminous combustion, which causes a less quantity of the acidifying principle to be absorbed by the phosphorus than in the case of rapid and fiery combustion.

3. It is a natural consequence of what has been just stated, that if the phosphoreous acid be phosphorus with a less portion of oxygen than the phosphoric acid, it may also be considered as phosphoric acid super-saturated with phosphorus, or holding in solution phosphorus not saturated with oxygen. We may, also, suppose two methods of preparing the phosphoreous acid. One method would consist in adding phosphorus to the phosphoric acid; but it has been shown in the preceding article, that this is not practicable, and that we cannot succeed by an immediate action; the other, which alone is practicable, consists in simply combining with phosphorus the necessary quantity of oxygen to reduce it to the state of acidification defined by the name of phosphoreous acid.

4. As the phosphoreous acid is never found native, it must be prepared artificially, by collecting, by means of a proper apparatus, the produce of the slow and merely luminous combustion of phosphorus in the air of the atmosphere. When phosphorus is exposed in the air, which is incessantly agitated and renewed around it, it begins, as we have before observed, to be dissolved in the azote gas; after which it
gradually

gradually combines with the atmospheric oxygen, and its acid, in a state of vapour, is carried away in the atmosphere, while its successive formation is attended with streams of light clearly distinguishable in the dark. But when this operation is performed in a closed apparatus, so that the air cannot circulate round the phosphorus, and into which the atmospheric air is but slowly admitted, and only in a proportion necessary to support the luminous combustion of this body, the acid which is formed envelops the phosphorus with a vapour white in the day and luminous at night, which condenses on the surface of the combustible body; which, by attracting the water of the atmosphere, becomes moist, dissolves, and speedily flows in small drops. These drops, when collected, constitute the phosphoreous acid, of which the proportion of constituent parts, phosphorus and oxygen, cannot be estimated in this operation, on account of the water which combines with the acid, and renders it liquid.

5. It may be easily understood that, in order to fulfil the conditions above specified, it is necessary to be provided with an apparatus that will gradually admit the air, and receive the acid as it becomes liquefied. These objects are attained by the following means: cylinders of phosphorus are placed in glass tubes, open at the top, and drawn into a point at the lower end, where they are also open: these tubes are arranged in a large funnel, so that their slender extremities

extremities are collected towards the pipe, which is inserted in a glass bottle. By this means, the pieces of phosphorus do not become heated by mutual contact, and are not subject to inflammation by the rapid combustion which often happens when they are exposed by the side of each other on the funnel. Over this funnel, and the bottle, which stands upon a plate, is placed a glass receiver with two small lateral tubes, provided with stoppers, which can be removed or closed at pleasure, according as it may be wished to increase or diminish the combustion. The bottom of the receiver is immersed in water which covers the plate, and, at the same time, furnishes the acid with an appropriate solvent. The liquid phosphoreous acid flows gradually into the decanter; and nearly three times the quantity of the phosphorus is obtained. From this process, before its difference from the phosphoric acid was accurately determined, it was called *phosphoric acid by deliquescence*.

6. The phenomena which accompany the phosphoreous acid, the feeble light, the insensible heat, so different from the burning ardor, and the vivid flame observed during the preparation of the phosphoric acid, prove that the phosphoreous acid is not distinguishable from the latter by a less proportion of oxygen alone, but also by the state of this acidifiant principle, which appears to be much less solid, and to retain much more caloric than in the phosphoric acid.

It

It will be seen that these two differences may lead to an explanation of their properties.

7. The phosphoreous acid, prepared by the process of Pelletier, which has just been described, is in the form of a thick white liquid, resembling a syrup, slightly adhesive, and forming streaks upon glass like an oil. Its consistence however varies according to the state of the air, which contributed to its formation. It is more liquid when the air is extremely moist. Its specific gravity has not been compared with that of the phosphoric acid, which appears to be rather more dense. Its acrid and pungent taste, which sets the teeth violently on an edge, is not very different from that of the phosphoric acid, from which it cannot be distinguished by the palate; nor can the excess of phosphorus be perceived by the same sense. It reddens blue vegetable colours nearly in the same manner as the phosphoric acid.

8. The phosphoreous acid is not affected by light, which it refracts more strongly than the phosphoric acid in proportion to its density. Caloric acts far otherwise upon it than upon the phosphoric acid, and it is by this action that the acids may be particularly distinguished. On exposing the phosphoreous acid in a glass retort, it first loses part of its water; when it is concentrated, there may be perceived suddenly to rise from the bottom of the vessel, a number of bubbles, which burst at the surface of the liquor, affording a white and thick smoke,

smoke, which sometimes takes fire, when there is a sufficient quantity of air in the apparatus. If the experiment be made in an open vessel, each bubble affords in the air, a vivid deflagration, and produces an unpleasant odour, which is apparently similar to phosphorated hydrogen gas. These inflammable bubbles continue for a length of time; and the phosphoreous acid cannot, but with great difficulty, be entirely deprived of that substance, namely, the phosphorus which forms them by its disengagement, so as to bring it to the state of very pure phosphoric acid. This point, however, may be obtained, by continuing the operation for a long time, after which the remaining acid will be found to possess all the properties of the phosphoric acid, which have already been stated. On making this experiment, it must be remembered, that the phosphorated gas is only volatilized, when the acid is well concentrated and very hot, which proves that phosphorus not saturated with oxygen strongly adheres to the acid.

9. There is only a very small degree of attraction and tendency to union between oxygen and the phosphoreous acid, though the latter is not saturated; this fact tends to show the great adherence of phosphorus to the phosphoric acid. It is without effect that the phosphoreous acid may be exposed to oxygen gas for this purpose; a small quantity of it only is absorbed, and that with extreme slowness. But

we cannot succeed in converting it by this means into phosphoric acid; which can only be done by a long ebullition; and even the glass made with the phosphoreous acid, appears to retain a portion of phosphorus, since it differs from that produced by the phosphoric acid, as it often emits a fetid odour like that of garlick, and emits rays of light on being rubbed in the dark, which effects do not take place in crystals of very pure phosphoric glass.

10. The same remark is applicable to the exposure of phosphoreous acid to the air. It changes with great difficulty into phosphoric acid, notwithstanding the tendency of azote gas to dissolve phosphorus, which must therefore in some measure weaken its combination with the phosphoric acid. The concentrated phosphoreous acid may be exposed to the air for several months, without being converted into phosphoric acid: this effect, however, takes place rather more speedily when the acid is diluted with a quantity of water. This scarcely changeable character of the phosphoreous acid, distinguishes it from several other acids, which might be compared with it on account of their weak acidification, and the superabundance of their radical.

11. Hydrogen and hydrogen gas have no action upon the phosphoric acid. Though experiments have not yet been made by heat, yet the law of the known attractions shows that hydrogen gas must carry off the excess of phosphorus

phorus from the phosphoreous acid, and be disengaged in the form of phosphorated hydrogen gas. The residue after mutual action of those bodies at an elevated temperature, does not differ from that which the phosphoric acid undergoes, for it arrives at that state.

12. The phosphoreous acid is decomposed by carbon at a red heat, which causes the separation of more phosphorus than from phosphoric acid, because it contains a greater quantity. No change is effected between those bodies at a cold temperature, neither can any combination be produced by heat, because the superabundant phosphorus escapes and volatilizes before it can unite with the sulphur. The diamond is no more changed by the phosphoreous than by the phosphoric acid.

13. When those metals which decompose water with greater or less facility, are brought into contact with the phosphoreous acid, diluted with that liquid, the difference between its action and that of the phosphoric acid, is evident, from the hydrogen gas which is disengaged. This gas holds in solution a small quantity of phosphorus, which renders it very fetid, without however, rendering it inflammable in the air, because the proportion of this combustible body, is not sufficient to produce that effect. By this discharge of the phosphorus, dissolved in hydrogen gas, we learn that the combination effected in the water, is only that of the phosphoric acid; because it is
deprived

deprived of the substance which is necessary to the constitution of phosphoreous acid.

14. The phosphoreous acid is soluble in water in all proportions. When it is proposed to drive off this liquid, in order to concentrate the acid, at the end of the operation, the phosphorus is disengaged, and the acid, as has before been mentioned, passes again to the state of phosphoric acid. Hence it cannot be obtained in a solid state; not so much on account of its adherence to the water, as because it loses at the same time by the action of the caloric, the excess of phosphorus which gave its distinctive character.

15. The phosphoreous acid combines with most of the metallic oxides, with which it forms salts, nearly insoluble. Some of these, however, even at a low temperature, impart a portion of their oxygen, so that while they approach to the metallic state, they at the same time convert it into phosphoric acid.

16. The phosphoreous acid is stronger than the carbonic, but weaker than the phosphoric acid: it seizes most of the bodies combined with the former, which it separates even from water, in the form of gas, and gives up to the latter most of those to which it may be united.

17. The uses of the phosphoreous acid are not yet distinguished from those of the phosphoric acid, except in chemical laboratories, where its attractions are examined, and are found as well as the compounds which it forms,

forms, to be different from those of that acid. It is also little known, and seldom employed in the arts. Some physicians prescribe it in the treatment of diseases; and though we are certain that its medicinal properties must differ from those of the phosphoric acid, they have not yet been ascertained by any accurate experiments.

ARTICLE VIII.

Of the Sulphuric Acid.

1. THE name of sulphuric acid expresses the combination of sulphur and oxygen, at the maximum of acidity. Hence the body consists of the radical sulphur completely saturated with the acidifying principle. It was formerly called *vitriolic acid*, because it was separated by distillation from its neutral combination with iron, which was called *vitriol*. When concentrated, and of a consistence nearly similar to that of an oil, it was, with much impropriety denominated *oil of vitriol*. Diluted with water, and in a weak state, it was distinguished by the equally improper and now obsolete name of *spirit of vitriol*.

2. This acid was unknown to the ancients. Pliny speaks of *vitriols*, which were employed in the hardening of bodies; and which by long lixiviation, must have admitted the separation

and disengagement of a portion of their acid. They burned sulphur at their sacrifices, but without being acquainted with its product. Basil Valentin was the first who spoke of it, at the end of the fifteenth century : he also made mention of the fulphureous acid. Agricola and Paracelsus likewise said a few words upon the same subject. But Dornæus was the first who in the year 1570, wrote upon it with precision. As it soon became one of the principal agents in manufacturing processes, all the chemists have been since aware of the necessity of examining it. Among those who more particularly employed themselves on this subject, Stahl deserves particular notice, on account of his application : but he adopted the error which long afterwards prevailed, that it is entirely contained in the sulphur. Lavoisier, in 1778, destroyed this notion, by proving that sulphur is one of its principles, and that it combines on burning with the base of pure air, or with oxygen, and forms the sulphuric acid : since this brilliant discovery, the properties and combinations of the sulphuric acid have been well understood.

3. The sulphuric acid has long been considered as the most abundantly distributed in Nature, and has been distinguished by the appellation of the universal acid, besides being considered as the common origin of all the other acids. This is another error which has been exploded by modern discoveries. It is known that

that the fulphuric acid exists in a pure state only in some volcanic places, in the environs of Sienna and Viterbo, near the Baths of Saint Phillip, in Italy, and above the surface of some fulphureous mineral waters; but this native acid is very small in quantity. On the contrary, it is very frequently engaged in a great number of saline combinations in the bowels of the earth, and in the waters which flow at its surface. The saline compounds, of which it forms a part, pass very frequently into vegetables and animals; but all its properties are then disguised, and it is necessary to employ different methods in order to discover and extract it.

4. As Nature does not afford the fulphuric acid in sufficient abundance for the uses of the arts, or chemistry, it is procured either by extracting it from some metallic salts, of which it forms a part, or by the complete combination of sulphur. The first-mentioned process consists in distilling the *sulphate of iron*, in earthen retorts, by a strong heat; it affords a very impure acid, as will be mentioned in the history of this metal. This operation was nevertheless the only one adopted for a long time, and it is still continued in Saxony. In the latter process, sulphur is burned by the addition of a tenth part of its weight of saltpetre. The art of chemistry has brought this process to great perfection; which derived its origin from the first ideas of Lefevre and Lemery, two French chemists. It has become the sub-

ject of one of the most useful of the chemical manufactures. At first sulphur was burned in large globes of glass; afterwards in chambers of wood, covered with lead, about sixteen metres (or yards) in length, by four or five in breadth, and as many in height. In proportion as the sulphur, placed upon grates of three stages, is burned by the nitre, and by the air of the chamber, the acid which is formed becomes dissolved in the water, at the bottom of the chamber, which is collected at one of the extremities lower than the rest of its floor. It is drawn out by a leaden tube, provided with a cock, which opens into a reservoir also of lead, placed in a work below the chamber of combustion. This work is fitted up with galleries, and large retorts of glass in which the acid is rectified; the water which is thus separated from it, is again used to absorb the vaporous acid in the chamber of lead.

5. The acid obtained by the processes above described, when very pure, has the form of a liquid without colour, and without smell; it is of an oleaginous consistence, and its specific gravity is to that of water, as 1840 : 1000. Its acid taste is so strong, that it burns and destroys the organs of animals, like the most powerful caustic. It reddens all the vegetable colours which are susceptible of that change. It blackens and reduces to a carbonaceous paste, all vegetable and animal substances, the organization
and

and composition of which it destroys, by the effect of an attraction which will be fully described in another section of this work. The sulphuric acid when of a yellow, brown, or black colour, fuming or odorant, like burning sulphur, is very far from being in a state of purity; it is soiled by some foreign substances: the more it departs from the properties which have just been pointed out, the less pure it is.

6. Though the sulphuric acid cannot be obtained dry and solid, on account of the processes made use of to obtain it, it follows, however, from calculations founded on the quantity of air employed, relative to that of sulphur, that 100 parts of this acid, supposed to be dry, and without water, contain 0,71 parts of sulphur, and 0,29 of oxygen. It is only necessary to remark, that on account of the extreme difficulty of establishing exact bases of calculation, this proportion must not be considered as equally accurate with those which have been given, relative to the composition of the carbonic and the phosphoric acids.

7. The sulphuric acid undergoes no alteration from light; the refraction which it effects, is relative to its density, and to the nature of the combustible radical which it contains. When this acid is deprived of caloric, it is susceptible of congealing, and even of crystallizing in prisms, with six sides, terminated by an hexahedral pyramid. To effect this, the acid should neither be too concentrated, nor too

too much diluted with water; at 1650 of specific gravity, it becomes solid at about three or four degrees under 0, of the thermometer of Reaumur. When its specific gravity is 1840, it never congeals, but at an extreme degree of cold.

Though the capacity of the sulphuric acid for caloric is very low, it may nevertheless be reduced to vapour, or gas not permanent. It is by this means that it is rectified in distillation. After the water which escapes from it at first, and the separation of which concentrates it, the acid itself having acquired about 120 degrees (centigrade) of temperature, rises, and is collected in the receiver, in the form of a white and thick fume, which condenses into a liquid. This vapour is so hot, that it acts upon glass, like a red-hot iron, and if the vessels should happen to be rather colder in one part than another, its contact is sufficient to crack them. By this distillation the sulphuric acid is procured in the purest state possible.

8. No attraction is known between the sulphuric acid and oxygen. When brought into contact with oxygen gas, this acid absorbs no portion of it, and it does not even absorb the oxygen from such bodies as are least adherent to it: hence it follows, that there is no oxygenated sulphuric acid, as some authors have been inclined to admit, on account of their having been deceived by inaccurate or illusive experiments.

9. By exposure to the air, the concentrated sulphuric acid absorbs the water from it so as to increase its weight nearly one half; this absorption is the more speedy and perceptible in proportion, as the air is humid. The foreign and often combustible bodies, which float in the air, frequently colour the concentrated sulphuric acid; but it does not act upon either of the two æriform fluids, which constitutes its mass and nature.

10. It has no action either upon azote gas, or azote, which it does not even disengage from several combinations, from which another acid, more weak however than it, separates this principle in the gaseous form, as will be mentioned in a subsequent article. Azote, though a combustible body, has therefore less attraction for oxygen than sulphur has, which will be confirmed by facts hereafter to be stated, proving that sulphur, in certain circumstances, actually carries off oxygen from azote.

11. A great number of facts prove, that hydrogen has more attraction for oxygen than sulphur has, and consequently, that it ought to decompose the sulphuric acid, particularly at a certain elevation of temperature; but as hydrogen cannot be had alone, and as, in its solid or liquid state, it always forms part of the compounds which render its action complicated, we can here only treat of the mutual action of gaseous hydrogen and sulphuric acid. At a cold temperature there is no attraction
between

between these bodies; hydrogen gas is neither absorbed nor altered by this concentrated acid. But if some sulphuric acid and hydrogen gas be passed through a porcelain tube, made red-hot, a decomposition of the former, or formation of water, and precipitation of sulphur take place, the last is seen deposited in abundance in the glass tube, affixed to the tube of porcelain. When hydrogen gas is employed in the proportion of more than one half of the sulphuric acid, there is not only a formation of water, but the excess of hydrogen gas dissolves some sulphur, and is disengaged in sulphurated hydrogen gas.

12. Carbon, when cold, has less attraction for oxygen, than sulphur has, or at least this attraction is nearly equal between the two combustible bodies and oxygen; because, on the one hand, carbon at a cold temperature, does not decompose the sulphuric acid; on the other, sulphur does not decompose the carbonic acid; yet carbon, at the temperature of ignition, decomposes the sulphuric acid: when a piece of lighted charcoal is plunged into this concentrated acid, a white and thick vapour is suddenly disengaged, consisting of volatilized sulphuric acid and water, accompanied with very pungent sulphureous acid gas, that is to say, the sulphuric acid losing a portion of its oxygen, which it imparts to the carbon, passes to its *minimum* of acidification; which is the sulphureous acid, while

while the burned carbon passes to the state of carbonic acid. As long as the sulphuric acid is liquid in this operation, there is only a disengagement of sulphureous acid, because in that case the carbon absorbs only a portion of the oxygen from the sulphur, which was saturated with it. But if these two bodies be treated at a high temperature, as in a porcelain tube, made red-hot, or if charcoal be strongly heated with very concentrated sulphuric acid, and particularly dry, as it exists in some compounds, there is then a complete decomposition of the acid, and sulphur, with carbonic acid only are obtained. But as sulphuric acid is seldom procured totally free from water, there is a disengagement of sulphurated hydrogen gas, on account of the double decomposition of these two bodies burned by carbon, and of the attraction of hydrogen for the sulphur, which acts at the same time as that of the carbon for oxygen.

13. Phosphorus, though possessing a stronger attraction for oxygen than sulphur does, cannot decompose the sulphureous acid but with difficulty, and after a length of time at the cold temperature. On leaving these two bodies in contact, the acid gradually changes to a brown colour, and partly assumes the sulphureous character. This decomposition succeeds better by heat; a quantity of sulphureous acid gas is obtained, which carries with it a portion of phosphorus, the greatest part of which is deposited

posited by cooling: the phosphorus remains at the bottom of the apparatus in the form of phosphoric acid. In this operation the sulphuric acid is but partly decomposed; it does not pass to the state of sulphur: the phosphorus, therefore, only absorbs that portion of oxygen which exceeds its constitution in sulphureous acid; and it is only to this latter part of the acidifying principle that it has more attraction than the sulphur has. Neither can it, as will be seen in the following article, decompose the sulphureous acid. It is therefore more accurate to say, that phosphorus has a greater attraction for oxygen than the sulphureous acid has, instead of affirming that its attraction is greater than that of sulphur for the same principle.

14. Sulphur forms no union with the sulphuric acid in the cold; but when these two bodies are heated, the sulphur is partly dissolved in the acid, which becomes converted into sulphureous acid. The proportion of sulphur it can take up, has not yet been determined. The sulphureous acid may be prepared by this process: it is disengaged in the gaseous form, from these two bodies, when heated together.

15. The diamond undergoes no alteration from the sulphuric acid at any temperature, and however long they may be suffered to act upon each other. The diamond does not appear, in this instance, to differ in its action from carbon, with which it bears a strong analogy in the product of its combustion, except in
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the extreme adhesion of its integrant particles.

16. The manner in which the metals act with the sulphuric acid, presents three classes of phenomena which it is necessary to study here in general. Some of them have no action either by heat or cold upon this acid; these are such as have but little attraction for oxygen. Others which have but little action upon it at a cold temperature, exert a very remarkable action by heat: the concentrated acid then employed is partly decomposed; a disengagement of sulphurous acid gas takes place; and the metal becomes oxidized, and united to the portion of undecomposed or insulated acid, if this acid be sufficiently abundant. At a very high temperature, the sulphuric acid is completely decomposed by these last metals, and a portion of sulphur is disengaged, or a metallic sulphuret is formed. And other metals, for instance, those of which the attraction for oxygen is the strongest, being assisted by the presence of the acid tending to combine with their oxides, become capable of decomposing rapidly, and at a cold temperature, the water with which the acid may be diluted; and these metals may exert this property without heat, or be capable of exerting it only when heated. In the third case, the effervescence is strong and rapid, and caloric is abundantly disengaged; much hydrogen gas is emitted: the metallic oxide, in proportion as it is formed, dissolves in the acid, which becomes

becomes concentrated, and is found entire after the solution. The hydrogen gas often carries with it some sulphur or carbon, which were combined with the metal; and sometimes even the metal is dissolved in this gas.

17. The attraction between the sulphuric acid and water is extremely strong, and the phenomena, afforded by their union, are well worthy of being carefully investigated. They depend on the intimate penetration that takes place between these two bodies, the expulsion of the caloric, which accompanies it, and the particular degree of attraction which exists between various doses of acid and water. As these phenomena, as well as their cause, are here exhibited with much energy, and may serve to facilitate the explanation of those which occur in several similar operations, I shall describe them with that precision which is necessary for an important subject of theory, which has been treated of too superficially, or even totally neglected by the writers on chemistry. If four parts of concentrated sulphuric acid be mixed with one part of ice at 0, an elevation of temperature is produced even at the moment of combination between these two bodies, and of the fusion of the ice, which rises as far as twenty-four degrees of Reaumur's scale. By experiment we learn, that the proportions, in the mixture above mentioned, are those which give the greatest possible heat; it proves that, in its union with the acid, the frozen water, though it becomes liquid, acquires a density much greater

greater than it possessed in its state of ice. By inverting the proportions, that is to say, of four parts of ice at 0, and of one part of concentrated sulphuric acid, the thermometer, when plunged in it, sinks to sixteen or eighteen degrees below 0. Notwithstanding the fall of the thermometer in this case, there is an equal proportion of heat disengaged as in the preceding experiment. But as this disengagement takes place, the caloric which, on abandoning one sixteenth part of the ice employed, in order to saturate the acid in the same manner as in the preceding experiment, ought alone to raise the temperature 20° above 0, is immediately absorbed, together with a portion of the heat of the surrounding bodies, by the other fifteen-sixteenths of the ice, which are fused in order to combine with the acid after the former sixteenth part which first united with it. It must be remarked, that the attraction between the concentrated sulphuric acid and ice, has, in common with all the other combinations, a point of *maximum* or of saturation; that this point is, in the present instance, when four parts of acid unite with one part of ice; that as, in the union of these two bodies at this dose, there is a strong condensation of their particles, there is also a great disengagement of caloric; that any portion of ice exceeding this rate of saturation, being less strongly attracted by the acid, will undergo less condensation, and lose less caloric; hence, it is, that there are eighteen
degrees

degrees of refrigeration, instead of the hundred and sixty degrees of heat, which calculation would give for the four parts of ice united to one part of acid, on the supposition that the acid could disengage from these four parts of ice, the same proportional dose of caloric as it disengaged from one-fourth part alone in the first-mentioned experiment. In order to render this double effect still more evident, which, at first view, seems contradictory, I shall observe, that when the concentrated sulphuric acid has arrived at the first point of saturation, which requires only one part of ice to four parts of acid, its attraction for fresh quantities of ice not being entirely satisfied, and undergoing only a proportionate diminution, there are successively disengaged from the mixture, quantities of caloric, capable of preventing the cooling to one hundred and seventy-six degrees, till the attraction is weakened to the point when no more caloric can be disengaged from the mixture; and the ice, which still tends to unite with the acid, is obliged to absorb a portion of caloric foreign to the two substances in combination, namely, from the surrounding bodies.

18. The effect of the combination between the sulphuric acid and liquid water, is always marked by a development of heat, because the circumstances that have just been pointed out, and which arise from the solid state of the ice, do not here exist. The mixture of water and sulphuric acid, which produces the greatest heat, consists

consists of four parts of acid and one of water, or the same proportion as was used for the ice. The temperature here rises to one hundred and twenty degrees, or nearly double that which is produced by ice: a portion of water is, therefore, suddenly reduced to vapour, with a small quantity of the acid, and this experiment is not without danger, when the mixture is incautiously made, as by pouring the water upon a large quantity of the acid, instead of gradually pouring the acid into the water. The motion and rarefaction are so sudden, that, in that case, a violent hissing is produced. The air dissolved in the water is expelled by the addition of the acid, and the density of the liquor which results from this combination, is proportional to the attraction which exists between these two bodies, and to the quantity of caloric which abandons them. Thus the specific gravity of the sulphuric acid, diluted with water, is never proportionate to the mixture of the two liquids; and though useful to be determined, for making known and comparing the degrees of force of this acid, it is not adapted to give the respective quantities of water and acid which are thus united. Accordingly, as the proportion of water added to the sulphuric acid is increased, and the effect of the condensation is less, the areometer indicates the quantities of this acid more accurately; namely, as it sinks deeper into it, and as it approaches nearer to 0. The taste and strength of the sulphuric acid diminish

nish in proportion to its dilution by water; and as the first quantities of this liquid, which are introduced, adhere more strongly, it is easily understood, that when it is exposed to the action of heat, in order to concentrate it, the first vapours of the water which are disengaged from it, abandon it much more readily than the latter, and are very difficult to be separated. In particular when this acid has arrived at such a degree of rectification, that it contains only the fifth part of its weight of water, it becomes necessary to increase its temperature in a considerable degree, in order to deprive it of this last-mentioned portion.

19. The sulphuric acid has a great attraction for metallic oxides in general; there are some from which it disengages a portion of oxygen when they are overloaded with this fluid, and when it cannot combine with them, except in a smaller degree of oxidation. It is even used, in some instances, for the purpose of extracting, from these oxides, the portion of oxygen which they are capable of affording, in a gaseous state by heat; there are others which it dissolves in whatever state of oxidation they may be. And, lastly, there are certain oxides which refuse to combine with it; such, in particular, are those which, when saturated with oxygen, are capable of becoming acids. Combinations of the sulphuric acid with the metallic oxides, form salts more or less acrid, soluble, and crystallizable, which

which will be treated of under the article of metals.

20. The sulphuric acid does not combine with the carbonic acid : being much stronger than the latter, it expels it from all its combinations, as well as from the water to which it is united. It disengages it in the form of gas, and with effervescence.

21. There is no union between the phosphoric and the sulphuric acids. These two liquid acids only mix together. The sulphuric acid attracts water from the phosphoric, and concentrates the latter by weakening itself. When these two acids are mixed, they are easily separated by the action of heat ; the sulphuric acid rises, and the phosphoric remains at the bottom of the distilling vessel, either in the form of a transparent, and, as it were, mucilaginous matter, or in that of glass, if the retort has been made sufficiently hot to melt it. The separation of the last portions of sulphuric acid requires a great degree of heat.

22. The phosphoreous acid, in the cold, undergoes no alteration from the sulphuric acid : the latter deprives the former only of a certain quantity of the water it contains. But when these two acids, mixed together are heated, at the moment when the sulphuric arrives at the state of ebullition, the phosphoreous deprives it of a portion of its oxygen, relative to the quantity of phosphorus which it contains, and passes entirely to the state of phosphoric acid, while

the decomposed part of the sulphuric acid is disengaged in the state of sulphureous acid gas.

23. The discoveries made relative to the sulphuric acid, from that of its origin, and the various methods of procuring it, to that of its intimate nature, or decomposition, have greatly contributed to the advancement of human knowledge, and the extension of the arts. The phenomena of nature have been better known, in the formation of the salts into which this acid enters, in the efflorescence, or spontaneous decomposition of pyrites and metallic sulphurets, by the contact of air, in volcanic productions, in the mineralization of metals, waters, &c. This acid speedily became an instrument, which industrious men have applied with success to a number of operations in the arts and manufactures; it has, itself, afforded the means of making a great number of successive discoveries relative to the nature of salts, their decomposition, and the proportion of their component parts; and it has become, one of the principal agents of the chemical processes of the laboratory.

24. Medicine, which has sought for preservative, palliative, or curative means, in all the productions of Nature and the arts, has employed the sulphuric acid, either concentrated, as a caustic, for burning, or disorganizing the parts in some external diseases, or when diluted with water, and mixed with different beverages, as
a cooling

cooling, antiseptic, and antibilious remedy, in a great number of internal disorders.

25. Sometimes, by unfortunate and dreadful mistakes, this acid has been swallowed in its state of concentration: it then acts as a very violent corrosive poison, and quickly disorganizes the viscera which it touches, or upon which it rests during a few minutes. The oils, gums, and mucilaginous drinks, which have continually been prescribed in these cases, only tend to fill the stomach, without sufficiently destroying the activity of this poison, which is so speedily destructive. Sope-water, which has been strongly recommended as an alkaline substance, always at hand in every house, to be used in cases of poisoning by acids is a much better remedy. It will be seen in the next section, that the earth, known by the name of magnesia, diluted in water with sugar, or mixed in water with syrup, is of all remedies, that which deserves the preference.

26. In pharmacy, the sulphuric acid, besides the simple mixtures which are prescribed by the physicians, serves for the preparation of a number of chemical medicines. In the manufactures and the arts, there are few substances which are so useful, or so frequently employed as this acid. It is, for this purpose, that in many manufactures and trades, a chamber of lead, destined for the fabrication of the sulphuric acid, is almost as necessary as most of the instruments, or utensils made use of in the labo-

ratories of chemistry. It would be useless and irregular, in this article, to describe the numerous arts in which the sulphuric acid is used; its application will be perpetually mentioned in the course of this work. It is, on account of its very numerous uses, that the manufactories of the sulphuric acid by the combustion of sulphur, have been so much increased during the last twenty years in England, Holland, and France.

27. It is fortunate for the wants of the arts which make so great a consumption, and which, having been accustomed to its use for more than thirty years, could not, at the present day, be deprived of it without the greatest misfortunes happening to the proprietors, that the fabrication of the sulphuric acid by the combustion of sulphur in chambers of lead, now almost generally substituted for the method of extracting it from the sulphate of iron by distillation, has attained such perfection, that immediately after this important discovery, the price of this acid underwent a diminution of nearly one-fifth of its first and ancient value. The construction of leaden chambers, their management and use, began to be so generally extended in the French Republic, that these ingenious works have increased so as to have nothing to require of improvement from neighbouring nations, the rivals of the glory and prosperity of the French nation, and even to supply this article to many of the states which surround the French territory.

ARTICLE IX.

Of the Sulphureous Acid.

1. THE termination of the name of this acid sufficiently indicates, that it is to the sulphuric acid, what the phosphoreous is to the phosphoric acid, that is to say, a combination of sulphur and oxygen less abundant than the preceding; —sulphur less strongly burned, an acid more weak, and containing less of the acidifying principle, an intermediate state, in a word, it is between the oxide of sulphur and the sulphuric acid. It has been distinguished by the names of *spirit of sulphur*, and *volatile sulphureous acid*.

2. Though the ancients discovered some of its properties, and often prepared it by burning sulphur in their sacrifices, or in their arts, yet Stahl was the first chemist who began to examine it with attention, in the early part of the eighteenth century. It is true, that, for near half a century, he established an erroneous doctrine with respect to its nature; but this was the error of a man of genius, since it led his successors to discover the truth. It was not till after 1774, and by the first accurate labours of Lavoisier, that this acid was known to be composed, like the sulphuric, of sulphur and oxygen,

oxygen, and that it differs from it only by a less proportion of this latter principle. Dr. Priestley long studied it under the form of gas. Citizen Berthollet afterwards made some important discoveries relative to this acid, its formation, decomposition, combinations, and uses. And, lastly, Citizen Vauquelin and myself, carefully examined several of its properties, particularly those of the saline compounds, which it is susceptible of forming: from these various investigations, it is one of the acids best known at the present day.

3. The sulphureous acid exists abundantly in nature; it is found in the environs of volcanos; is disengaged from some lavas in fusion, from sulphurated and hot soils; it was the vapour of this acid which suffocated Pliny the naturalist, in the famous eruption of Vesuvius, by which Herculaneum was swallowed up in the 79th year of the Christian era, and of which Pliny the advocate, his nephew, has given such a beautiful description.

4. Notwithstanding this abundance of the sulphureous acid in nature, as it is disengaged and dissipated in the air, in the form of an elastic fluid, it is artificially prepared for the arts, and in chemistry. There are two processes for obtaining it. One consists of slowly burning sulphur over water, which becomes loaded with sulphureous acid gas, in proportion as it is formed. This acid was, also, formerly prepared in a similar way, under the name of *spirit of sulphur*
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by the bell, because sulphur was burned under a bell-glass moistened with water; but this tedious operation, by which a quantity of acid was lost, was subject to the inconvenience that only a very small quantity was afforded, and this was often mixed with sulphuric acid. The other class of processes, which are far preferable, and are the only ones employed at the present, consist in the decomposition of the sulphuric acid by many combustible bodies. It is known, that most of these bodies deprive it of the portion of oxygen, exceeding that which constitutes the sulphureous acid, so that they bring it to the state of this latter acid.

5. A great number of different combustible bodies may be used, for thus partly decomposing the sulphuric acid, and reducing it, by the subtraction of a part of its oxygen, to the state of sulphureous acid. All vegetable and animal substances may serve for this purpose; but as by various vapours, and particularly by the carbonic acid which they afford, they may contaminate the sulphureous acid, when required to be obtained in the form of gas, we should prefer a metal, which has not this inconvenience. One part of crude mercury, and two parts of concentrated sulphuric acid, are put into a small glass retort, with a long neck; this is passed under receivers full of mercury, supported by an hydrargyro-pneumatic tub; and the bottom of the retort is heated, till an effervescence is produced. When the acid is boiling,

ing, the mercury begins to decompose it, and, in proportion as it becomes oxidized, there is a disengagement of sulphureous acid gas, which is collected in the receivers. In order to explain this decomposition, it might be said, that the mercury absorbs from the acid its *sulphuric* portion of oxygen, and leaves it the sulphureous portion.

6. The sulphureous acid thus obtained, and fused in caloric, has the form of gas; it weighs a little more than double that of the air; this excess proceeds to 0,17 more than double the quantity. So that if a certain volume of air weighs 0,46, the same volume of sulphuric acid will weigh 1,03. It has a sharp and acrid smell; this is well known in the blue combustion of sulphur, which is there in the act of affording this acid. Its taste is harsh, it reddens blue vegetable colours, and destroys most of them: the vapour of sulphur, in a state of combustion, is also employed for taking out the stains of fruit from linen, the sulphureous acid also forms one of the most useful articles in the art of bleaching. When received in the mouth, or up the nose, it produces sneezing, cough, and causes tears to flow: it suspends the animation of, and kills animals. As far as it has hitherto been ascertained, one hundred parts of this gas contain nearly 0,85 of sulphur, and 0,15 of oxygen.

7. The sulphureous acid gas strongly refracts the light without being changed by it: it is dilated,

lated, or rarefied by caloric, and is susceptible of liquefaction at 28 degrees of cold. This latter property discovered by Citizens Monge and Clouet, and by which it is distinguished from all the other gases, appears to be owing to the water which it holds in solution, and to which it adheres so strongly, as to prevent an accurate estimate of the proportions of its radical and acidifying principle. According to my experiments, when strongly heated, as in a red-hot tube of porcelain, it remains without alteration. Priestley and Berthollet assert, that it deposits sulphur by long exposure to heat.

8. It does not immediately absorb oxygen gas when it is itself in a gaseous form, but can alone absorb oxygen from several bodies which are overloaded with it, and, by this means, re-pass to the state of sulphuric acid. It will, also, be seen that, in the fluid form, it more perceptibly absorbs oxygen. It has no action upon azote, nor azote gas, and, in consequence of these two nullities of effect upon oxygen and azote gases, it undergoes no alteration by air. By passing sulphureous gas and oxygen gas through a red-hot earthen tube, sulphuric acid is again formed.

9. In the cold and by simple contact, there is no action between the sulphureous acid gas and hydrogen gas, but at a high temperature; for instance, by passing these two gases through a red-hot tube, sulphur is suddenly deposited, and water is formed. If the proportion of hydrogen
gas

gas be much superior to that of the oxygen contained in the fulphureous acid gas, a disengagement of fulphurated hydrogen gas takes place.

10. Carbon has no action in the cold upon fulphureous acid gas; when red-hot it completely decomposes it, as when the gas is passed through an earthen tube, containing charcoal, and made red-hot. Some sulphur is deposited in crystals, and carbonic acid gas is formed in this operation.

11. Phosphorus does not act in any manner upon fulphureous acid gas; it has been seen that phosphorus absorbs the portion of oxygen from the sulphuric acid which exceeds its state of fulphureous acid; and that it brought the first of these acids to the state of the second, without producing any for the change. Phosphorated hydrogen gas is decomposed by fulphureous acid gas. By the mixture of these two gases a white and thick smoke, or solid phosphorated sulphur is deposited in a dense white smoke, and water is formed. The attraction of the sulphur for the phosphorus is here seen to perform the part of a double attraction.

12. There is no attraction between sulphur and fulphureous acid gas. These two bodies cannot be combined by any process, and consequently the acid cannot thus be brought again to the state of oxide of sulphur, as the theory might seem to indicate. Sulphurated hydrogen gas, even at the instant of contact, is decomposed

composed by the sulphureous acid gas; both become condensed, turbid, and deposit solid sulphur and water; the caloric being set at liberty. We here again observe the effect of a double attraction, generated without the application of heat, between two binary compounds.

13. The diamond undergoes no alteration on the part of the sulphureous acid gas; the greatest part of the metals also remains untouched by it; the water which this acid always holds in solution, does not render them more alterable. It is only the strong attraction of some of the metals for sulphur which causes this acid to be decomposed by several metallic substances, as will be seen more fully hereafter.

14. Most of the metallic oxides (of which I here speak before I mention the action of water, because this last requires to be entered into more minutely, and even refers to a previous knowledge of the attraction of these oxides) have an action upon sulphureous acid gas which sometimes depends upon their attraction for the sulphur, and sometimes upon their small attraction for oxygen, which they then yield to the sulphureous acid. In both cases, this acid passes to the state of sulphuric acid, but with this difference, that in the latter, pure metallic sulphates are formed; in the former, on the contrary, the salts are mixed with metallic sulphurets, and are species or sulphurated metallic sulphates; because, in that case, a portion of sulphuric acid is formed only at the expence of the
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the portion of sulphur exceeding this acid in the sulphureous acid.

15. Water has much attraction for the sulphureous acid gas. Ice, when put in contact with it, melts with scarcely any change of its temperature. Fluid water absorbs and liquefies it very easily. As it is extremely convenient to preserve and employ it, when condensed in this liquid form, for a great number of experiments, or operations in manufactories, it is prepared in this form by causing the sulphureous acid gas which is disengaged during the decomposition of the sulphuric acid, heated with combustible bodies, to be passed into decanters, or vessels filled with cold water. It is first passed through a very small vessel full of water, in order that it may deposit the portion of sulphuric acid much more soluble than itself, which it always holds in a state of vapour. The sulphureous acid gas, deprived of this acid, arrives pure at the second vessel, which is of a tall and narrow figure, to facilitate, by pressure, the condensation of the gas in the water. When the effect of the tubes, which conduct this gas to the bottom of this liquid, is observed, we may perceive bubbles of sulphureous acid gas, of a very large size in this lower region, diminish in bulk and disappear, by becoming fixed and liquefied before they arrive at the surface of the water. This liquid absorbs the more of this gas in proportion to its coldness. At 4 or 5 degrees $+ 0$, it may take up one-third

third of its weight. Water absorbs but very little at 75 degrees, and at 100 degrees the absorption ceases : there is but a very small quantity of caloric disengaged during the fixation of the sulphureous acid gas in liquid water.

16. In this state of liquidity, improperly called solution, it ought to be denominated sulphureous acid, as is done with regard to all the other acids under the liquid form. This is the form in which it is most frequently employed, and of which the properties are requisite to be known. The gas thus liquefied does not much increase the weight of the water, from which it disengages but little caloric on becoming fixed. Bergmann asserts that this liquid acid has the specific gravity of only 1,00246, and adheres to it so forcibly that the freezing temperature cannot expel it, as it does the carbonic acid. It is also necessary to heat it much more than this latter solution, in order to separate the sulphureous acid from it in the gaseous form. It gives out a much less quantity of bubbles, and with much less readiness than that acidulous water, by subtraction of the weight of the air in the pneumatic machine. The liquid sulphureous acid has the smell, taste, and discolouring property of sulphureous acid gas. It gradually absorbs oxygen either in a state of gas, whether pure, or mixed with atmospheric air, and passes, though very slowly, to the state of sulphuric acid ; this effect takes place the more readily, the more it is diluted with water, and the more it is agitated

tated in contact with the air. In other respects, this acid liquor acts in the same manner as the gas itself upon combustible bodies, by the assistance of heat, which causes it to assume the gaseous form. In a cold temperature, it decomposes the phosphorated hydrogen and sulphurated gases, and precipitates from them either phosphorated sulphur or pure sulphur.

17. The sulphureous acid, whether gaseous or liquid, is stronger than the carbonic acid; it separates it from its bases and from water. The sulphureous acid gas, received in the liquid carbonic acid, takes its place, and disengages it in gas.

18. It is weaker than the phosphoric and the phosphoreous acids, which expel it from the combinations in which it is engaged, without any alteration being produced in either of the substances.

19. As it is much less strong than the sulphuric acid, it is disengaged by the latter with effervescence, in the form of gas, from its combinations, and even from water. The concentrated sulphuric acid absorbs the sulphureous acid gas, which colours it yellow and brown, and renders it odorant and fuming. These two acids attract each other so strongly that, when submitted to the action of heat, the first vapour which rises crystallizes in long, white, needled prisms in the cool receivers. This singular concrete acid, which is obtained by distilling certain black and fuming sulphuric acids of Saxony,

Saxony, such as that of Northaufen, is a combination of the fulphuric and fulphureous acids. It smokes in the air, and when the atmosphere is very humid, it quickly dissolves with an appearance of ebullition. It has a strong smell of fulphureous acid; when thrown into water, it makes the same noise as when a hot iron is plunged in it. If the water be aerated, and employed in abundance, the acid loses its property of smoking, and ceases to be fulphureous. It is made artificially, and its compound nature of fulphuric and fulphureous acid is ascertained, by loading the first of these acids with fulphureous acid gas, and distilling, at a gentle heat, after it has been rendered fuming by this combination. I have published this circumstance in a particular memoir.

20. The fulphureous acid is much employed in the arts, and in medicine. In gas, it serves for discolouring and bleaching, particularly silk and woollens. It takes out vegetable spots and iron-mould from linen. Physicians prescribe it as an attenuant, particularly in affections of the lungs; it is not improbable that it may sometimes act in the animal economy, by absorbing an excess of oxygen which probably causes some kinds of diseases.

It must have been seen by the details, presented in this article, that the exact knowledge of this acid has very much contributed to the advancement of science, and had great influence upon the progress of natural philosophy.

ARTICLE X.

Concerning the Nitric Acid.

1. THE acid which is distinguished by the name of the nitric was unknown till the confirmation of the pneumatic doctrine. It was confounded, in general, with what was called spirit of nitre, and even with the nitrous acid ; as the method of preparing it was even unknown. It might, perhaps, have been proper to change the name of this acid, and call it the azotic acid, according to the rules of the methodical nomenclature, on account of its radical azote ; but I have, elsewhere, observed, that this last name not being considered as the best which might have been applied to that combustible base, it was not thought proper to admit this change, and renounce the generic expression of nitre so long adopted, for another term which did not appear sufficiently accurate.

2. As it is only in consequence of the experiments and principles of the modern French chemists that we have acquired a knowledge of the nitric acid, its accurate history does not date far back ; at most to the year 1774 or 1776. It is to the successive experiments and discoveries of Priestley, Lavoisier, Cavendish, and Berthollet, that we are indebted for our positive knowledge

ledge acquired on the nature of this acid. It is known to be formed by the radical, azote, united to complete saturation with oxygen, so as to contain 20 parts of the former, and 80 of the latter. In our arrangement it occupies the fourth rank among the acidifiable bases, because it is entitled to this order from the attraction of its base to oxygen, compared with the three other acidifiable bases, carbon, phosphorus, and sulphur.

3. The nitric acid exists abundantly in nature, which forms it incessantly by uniting azote to oxygen; more particularly among vegetable and animal matters which putrefy slowly. This is the general theory of natural or artificial nitre beds; but the acid is never found pure. It is united to several earthy and alkaline bases; so that there is no other method of obtaining it, but to extract it from these natural compounds.

4. There is no doubt but that, at some time hereafter, the art of preparing it artificially by combining azote and oxygen in a direct way will be discovered, though, in the preceding section, it has already been shown, that these two bodies, in the state of gas, cannot unite by simply remaining in contact. Mr. Cavendish discovered that by electrifying a mixture of these two gases in the proper proportions, their bases, by a certain time of electrifying, will abandon their caloric, combine together and form acid: which alkaline solutions speedily absorb, so that

the volume of the elastic fluids will gradually disappear.

5. It is not easy to give a reason, or apprehend the cause of the result of this beautiful experiment which, in connection with those of Priestley, Lavoisier, and Berthollet, has thrown the greatest light on the composition of the nitrous acid. It is not yet sufficiently known in what manner the electric fluid acts. It sometimes is seen to reduce liquids into gas, to separate and fuse together two combined gasifiable matters, and, in other instances, it causes the bases to assume the elastic form, and favors their mutual union.

6. It is only by means of the chemical attractions that we obtain nitric acid. It is extracted from saline combinations, in which it is engaged; more particularly from that which is commonly known by the name of nitre, to which a stronger acid is in this operation applied. The sulphuric acid is chosen for this purpose: it seizes its base, and disengages the nitric acid in the form of vapours, which are condensed in the receiver. This operation will be spoken of more in detail in the section of salts. It is sufficient to notice, in this place, that it is prepared, or extracted by distillation, and purified by heating it gently, till all the colouring matter is driven off, as well as a certain quantity of water which weakens it.

7. The nitric acid, thus prepared, has the form of a colourless liquid possessing the specific gravity

gravity of 1,5 water being denoted by 1,0. Its acid taste is so sharp and caustic, that it burns and destroys organized matters. When less concentrated it constantly gives to those substances a tinge more or less yellow, and it reddens and destroys blue and most other vegetable colours. One of the distinctive characters which it preserves until reduced as low as 1,3 of specific gravity is, that it emits a fume or white vapour of a caustic, austere, disagreeable, and nauseous smell; whence it may be seen, that by the assistance of its simple physical properties, the nitrous acid is easily and with certainty distinguished from all other acids.

8. This acid, when exposed to light, refracts it in a ratio somewhat greater than would follow its density. When it remains long in contact with light, the temperature being at the same time superior to 20 degrees, it begins to undergo a decomposition; a small portion of oxygen gas is disengaged, and the acid acquires a yellow or bright orange colour, by passing in part to the state of nitrous acid.

9. Caloric dilates and volatilizes the nitrous acid without changing its nature, when the temperature is not very high; but if this be raised strongly, as when the acid is passed through an ignited earthen tube, it separates into its two gaseous principles, and the result is an elastic fluid, favouring combustion more than the atmospheric air, on account of the great proportion of oxygen gas which it contains. This ef-

fect of accumulated caloric on the nitric acid, does take place on any other acid yet examined, and proves that its two principles which are both fusible in the form of gas, are but slightly adherent to each other; and agrees with the experiments which show that azote and oxygen in their nitric union, lose but a small proportion of the solvent caloric, and are very much disposed to assume the form of gas.

10. There is no action between the nitric acid, oxygen, and azote. These two bodies in the gaseous state are neither absorbed nor altered by the contact of this acid, which itself likewise undergoes no alteration whatever by such treatment. As it is the saturated combination of these two substances, it is a natural consequence that it should have no further attraction for them. Some compounds, more especially the class of animal matters, lose their azote by the first impression of the nitric acid upon them, which principle is then disengaged under the form of azote gas. From this property, chemists frequently use diluted nitric acid, to obtain azote gas from animal substances.

11. When concentrated nitric acid is exposed to the air, the vapour which exhales from it, combined with the moisture of the atmosphere, forms the white fume which is seen, and which gradually becomes condensed in the liquid form. The acid itself absorbs and condenses the water of the atmosphere, which uniting
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with it, weakens its specific gravity, at the same that it adds to its weight. When the surrounding air is saturated with the vapour, and the acid, with the atmospheric water, an equilibrium is established, in consequence of which no further attraction goes on, and the acid ceases to emit fume.

12. Hydrogen has a much stronger attraction for oxygen than azote has, whence it decomposes the nitrous acid, though merely at an elevated temperature. If this acid and hydrogen gas be at the same time passed through an ignited porcelain tube, inflammation and detonation takes place; water is formed, and azote or the nitric radical is separated. As the same phenomenon of inflammation and detonation does not take place with the phosphoric and sulphuric acids, though hydrogen gas decomposes them by the same process, it is evident that it is owing to the almost gaseous state, or at least to a disposition to assume this form, which the azote and the oxygen present in the nitric acid, as has already been remarked.

13. It is to the same cause and state, that the manner in which carbon rapidly decomposes nitric acid, at an elevated temperature, is owing. At a red heat it is suddenly set on fire by this acid, and the products are carbonic acid, and azote gas. Phosphorus and sulphur exhibit similar effects when treated by heat, or by fusion with the nitric acid, which immediately

diately inflames them by virtue of the caloric retained by its oxygen; and converts them into sulphuric and phosphoric acids. But the same rapidity of decomposition does not take place, if these combustibles be treated in the cold nitric acid, or with the same acid gently heated. They do not then seize the whole of its oxygen; but they absorb only a portion, and convert it to the state of nitrous acid, or nitrous oxide, according to the proportion they have absorbed. By this gentle and more moderate action, phosphorus and sulphur are slowly converted and burned into phosphoric and sulphuric acids. It is one of the best processes which can be adopted to obtain phosphoric acid in a state of purity, and with speed; that is to say, by throwing one part of the phosphorus, in small pieces, into four parts of the nitric acid successively, till each of them has lost its form, and becomes confounded with the whole of the acid liquid. This mixture of the nitric and phosphoric acids, is then to be heated, in order to draw off the former, and obtain the latter separate.

14. No action takes place between the nitric acid and the diamond, whatever temperature may be applied.

15. Most of the metals decompose nitric acid at all temperatures, some of them even take fire by its contact when in a state of division and heated; most of them take from it a portion of oxygen, which exceeds its state of oxide,
and

and themselves by that means become converted into oxides ; in some instances separating and falling down in powder, and in others remaining in solution in the undecomposed portion of the acid. The results are metallic salts, which will be described in another section ; the metals are used to effect this semi-decomposition of the nitric acid, and to reduce it to the state of oxide and azote, which will hereafter be examined. Some of the metals which are the most greedy of oxygen, require the greatest quantity to saturate them, and completely decompose the nitric acid, and reduce it to its radical, which is then disengaged, in the form of azote gas.

16. Water unites easily, and in all proportions with the nitric acid. This strong attraction is indeed the cause why it is never obtained in the form of gas, but constantly in that of a liquid. If ice at the temperature 0, be mixed with one fourth of its weight of nitric acid, of the specific gravity of 1,40, sixteen degrees of cold are produced, when the mixture is plunged into a bath, formed of one part of salt, and three parts of ice. If into the first mixture, thus cooled to 16 degrees, a second be plunged, consisting of the same proportions of four parts of ice, and one part of concentrated acid, this last descends to 22°. And if lastly, a third bath be made, into which a third similar mixture of ice and acid be plunged, 30 degrees of cold are produced, by which means mercury may
be

be frozen. Four parts of acid, and one part of ice, or the inverse mixture of the former, afford a degree of heat somewhat less than is produced by the sulphuric acid, and accordingly the cold is less intense than with those of the first mixture of the nitric acid. When concentrated nitric acid is added to liquid water, there is constantly a disengagement of caloric; the acid is weakened, loses its energy, and its weight, and fumes less, or ceases to fume entirely. Its mixture, as well as that of the sulphuric acid, diluted with water, is of greater density than the mean calculated between the two separate liquids. This diluted acid constitutes the aqua-fortis of commerce. In fact, this aqua-fortis is almost always impure, and mixed with various foreign acids, on account of the manner in which it is prepared, as we shall observe in the history of salts. The water united to the nitric acid, may be separated by distillation, and the acid concentrated like the sulphuric acid; but less heat and more caution are required to be used with this acid than with the latter, because the nitric acid being more volatile than the sulphuric, rises more easily with the water. Nevertheless, by this process, nitrous acid, of the specific gravity 11, which does not fume at all, may be easily raised to $14\frac{1}{2}$, and made to fume abundantly.

17. The nitric acid dissolves a certain number of metallic oxides, and forms salts, but it does not in general act upon those which are overcharged

overcharged with oxygen, or adhere strongly to that substance. Often indeed when it holds some of these in solution, it easily suffers them to fall down, and it frequently happens, likewise, that those of the metallic oxides, which are not saturated with oxygen, but are strongly attractive of that principle, decompose the nitric acid, and take from it a portion of oxygen, so as to reduce to the state of nitrous acid. This never happens but with such metallic oxides as are far from being saturated, and of which the attraction for oxygen is at the same time very strong.

18. On account of its much greater strength than the carbonic acid, the nitric acid expels it from all the bases to which it is united, and as it then assumes the form of gas, a very lively effervescence is produced. It also separates the phosphoric acid from its combinations, and disengages in the liquid form; sometimes the separation is only partial. We shall return more fully to this fact under the article of phosphorus, in the fifth section.

19. The phosphoreous acid, which, as is well known, is simply the phosphoric acid, holding a small portion of phosphorus in solution, is speedily converted into phosphoric acid, by the addition of concentrated nitric acid, which burns its excess of phosphorus. If the nitric acid be weak, it is necessary to employ heat. This is the process to which I give the preference, in point of cheapness, for obtaining
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without loss, as well as without danger to the operator, the phosphoric acid in a state of purity. I suffer, according to the method elsewhere pointed out, phosphorus to burn in the air, and become converted into phosphoreous acid. I then treat it in a retort with one eighth of its weight of nitric acid, at the specific gravity of 1,3, and I distil by a gentle heat, to burn all the excess of phosphorus, and disengage the nitric acid, of which part exhales in oxide of azote. The phosphoric acid remains pure and concentrated at the bottom of the distilling apparatus.

20. The sulphuric acid, of which the attractions are in general much stronger than those of the nitric acid, does not, however, produce any change in this last. When mixed with it there is a disengagement of caloric, because the sulphuric acid in its concentrated state, seizes the water of the nitric acid, and condenses it more than it was condensed in its union with the latter. The nitric acid is therefore condensed by the addition of the sulphuric acid, and by this means it becomes stronger and more capable of producing certain effects in chemical operations.

21. The nitric acid acts otherwise on the sulphureous acid; it not only is much stronger than this last, so as to separate it from water and its several combinations, but it has also the property of supplying it with oxygen, and converting it into sulphuric acid, at the same time

time that itself passes to the state of oxide of azote. For this reason it is, that nitric acid, poured into sulphuric acid, which is frequently rendered impure by a mixture of sulphureous acid, purifies it, and renders it clear, by completely burning not only the excess of sulphur which it contains, but even the other combustible bodies, such as charcoal and hydrogen, which it sometimes contains. But we must not consider this mode of purification which is frequently used in the arts, as certain and useful in chemistry, unless the sulphuric acid be afterwards heated sufficiently to disengage all the nitric acid, and oxide of azote, which it contains after the addition of the nitric acid.

22. It is not sufficient that the student should be thus acquainted with the properties of the nitric acid in its entire state. As it is the most decomposable, though the most oxygenated of the known acids, because its two originally gaseous principles have lost but little caloric in their mutual combination, and no doubt, for this reason adhere but weakly to each other, it is easily decomposed by almost every combustible substance, which seizes its oxygen more or less easily; in some instances burning even with flame in proportion as they absorb the oxygen into a more solid state than it existed in the nitric combination. It is therefore of importance to describe carefully the phenomena of this decomposition, which at the same time that it throws light on a number of operations,

operations, will have the advantage of rendering the history of acid of nitre more clear and complete.

23. When we announced that the nitric acid is a compound of 20 parts of azote, and 80 of oxigen, and showed that from the slight adherence of these two bodies, it ought to prove the most burning of all the acidified compounds, and that when completely decomposed by combustible bodies, so as to have lost the whole of its oxigen, it is reduced to the state of its pure radical or azote gas, in proportion to the disengagement of caloric which always takes place in these operations.—I was careful to remark, that the greatest number of combustible bodies do not deprive it of all its oxigen, but seize only the quantity which constitutes the acid form, and leave it that portion which is requisite to give it that of the oxide of azote. As this species of oxide which I have only pointed out at the third article of this section, cannot be prepared at least in sufficient abundance to examine it well, unless by the partial decomposition of the nitric acid, it will be proper to give an account of it in this place.

24. Dr. Priestley, by receiving under glass vessels filled with water, the gas which they disengaged in the action of the nitrous acid on the metals, discovered the fluid which he denominated nitrous gas, which is truly the oxide of azote, or nitric acid disacidified. It
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was afterwards ascertained by Lavoisier, that in this case the metals seize near half the oxygen in the nitric acid; that out of 80 parts of this principle, they take near 37, and consequently the nitrous gas, or oxide of azote, which results from this last decomposition, as I have already on several occasions observed, is a compound of 32 of azote, and 68 of oxygen. This disacidified body, though it contains of oxygen twice the weight of its radical, proves that azote is in fact infinitely less acidifiable than most of the other combustible bases, and forms when we consider it under this new point of view, an acid so decomposable, only because its saturation requires so large a dose of the acidifying principle; a circumstance which shows the weakness of its adherence.

25. This oxide of azote has been in several instances composed without nitric acid, by decomposing at an elevated temperature, as in porcelain tubes made red hot in the fire, mixtures of substances composed of azote, and other oxygenated matters, as will hereafter be shown; but the most expeditious and most convenient process consists in treating combustible, metallic, or vegetable bodies with the nitric acid somewhat diluted, and adapting to the containing vessels, glass tubes plunged beneath inverted vessels of water.

26. The oxide of azote thus obtained is a gas, weighing near 0,07 more than air, of a disagreeable styptic taste, and strong smell, similar

similar to that of nitric acid, refracting the light without being decomposed, dilatable by heat, and not decomposable by fire, even at the temperature of the red-hot tube, through which it passes without alteration, though the entire nitric acid is completely decomposed. Citizen Van Marum found that nitrous gas through which the electric spark is passed, is reduced to one third of its volume, and converted into azote gas and nitrous acid. This gas is not acid itself, and does not redden blue vegetable colours; it is not soluble in pure water; it extinguishes most inflammable bodies, and deprives animals of sensation; it opposes the putrefaction of animal bodies as a strong antiseptic.

27. The most permanent character which is the most remarkable and essential to be known in the oxide of azote, or nitrous gas is, that it again forms the acid by the mere contact of oxygen gas. These two mixed gases penetrate, become condensed, suffer the disengagement of caloric, and become changed into a red orange-coloured acid vapour, which reddens blue colours, is soluble in water, and is not a nitric but a nitrous acid. In order to acidify in this manner, the oxide of azote requires the proportion of oxygen which is wanting, namely, near two thirds of its weight. This very singular phenomenon proves, that the oxide of azote is very different from azote gas, which does not combine with oxygen
gas

gas, but by long electrization. It also explains why, when a solution of metal is made, or when a combustible body in general is treated with the very clear nitric acid in an open vessel, there is a production of red vapour in the air, of which the oxygen gas is at once condensed into nitrous acid by the contact of the nitrous gas which rises; whereas when this operation is made in a close vessel, no red vapour is seen, after the small portion of air which may have been contained in the vessel, has been consumed by the first portion of oxide of azote that rises.

28. The rutilation or formation of red vapours by the mixture of oxygen gas, is a kind of flame, which being accompanied with the disengagement of caloric, represents a species of combustion, and shows that the oxide of azote is much more combustible than azote gas; this last being combustible only by the assistance of electricity; the cause no doubt depending on the dense state of the azote in the nitrous gas, and the increase of its attraction for oxygen by that means. We must observe elsewhere, that in this true combustion the oxygen gas loses only a small portion of caloric; for by comparing the proportion of ice fused by the heat, which is separated in this combustion from that which would be disengaged from the same quantity of oxygen gas, during its fixation in phosphorus, Lavoisier found that it is only one ninth part, so that
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there remains in the nitric acid near eight ninths of the caloric belonging to the oxygen gas, which enters into its composition.

29. It was natural to believe, that nitrous gas having the property of seizing the oxygen gas, and of forming with it nitrous acid, might serve to point out the proportion of this last contained in a given quantity of atmospheric air. It has, accordingly, been proposed, as the instrument of eudiometry; but it was soon ascertained that this method is not to be depended on, as well on account of the variable nature of nitrous gas, which may contain more or less azote gas, according to the manner in which the nitric acid has been decomposed, as from the various proportions of nitrous gas which is dissolved in the nitric acid thus formed, which constitutes the nitrous acid in the red vapour, a proportion which may vary by a number of circumstances. This eudiometric process is, therefore, almost totally renounced, more especially since many other more certain and less fallacious methods have been discovered; nevertheless, on comparing the various eudiometric methods with each other, Mr. Humbolt thinks that nitrous gas is one of the best methods of ascertaining the proportion of oxygen gas contained in the atmosphere, when, by other means, the quantity of azote gas, as contained in the nitrous gas, is first determined. This may accurately be done by examining it, first by a solution of sulphate of iron, which absorbs the nitrous gas alone, and leaves the azote gas. I shall return in the history

history of iron, to this property of absorbing the nitrous acid which the fulphate of that metal possesses.

30. The oxide of azote, or nitrous gas, does not act in any manner upon azote. When mixed with hydrogen gas, it gives a green colour to its flame. When both are introduced together in an earthen tube made red-hot, they take fire, and afford water and azote gas.

31. It has no action in a common temperature on carbon, phosphorus, and sulphur. At an elevated temperature it burns them, and converts them into acids, while itself passes to the state of azote gas. It burns by the simple contact of the sulphurated and phosphorated hydrogenous gases, and affords water, phosphorus, sulphur, and azote gas. It does not decompose carbonated hydrogen gas. The property of decomposing sulphurated and phosphorated hydrogen gases, which nitrous gas possesses by becoming itself, at the same time, reduced to azote gas, a property which is not found in nitric acid, proves that the oxygen adheres less to the azote in the nitrous gas than in the nitric acid. It seems, at first consideration, that this assertion is contrary to the general theory, which demands that the first portions of the body should adhere more strongly than the latter, but this contradiction is here merely apparent, and depends on the oxygen, and the azote of the nitrous gas being in another state than in the nitric acid. It appears, that it is to the calo-

ric, added at the moment of the formation of the nitrous gas, that the easy separation of its principles is owing. We shall see, that this consideration is sufficient to explain the differences that exist between the nitric and the nitrous acids.

32. The oxide of azote does not act on the diamond; most of the metals are not altered by it. The most combustible, however, are oxidized in process of time, and reduce it to the state of azote gas. When the metallic sulphurets in a very divided and moist state are plunged in it, these bodies gradually divide the two principles into insulated gases, and, after some days, the elastic fluid is found to consist of air in a purer state than common air. At length, however, the oxygen gas is absorbed, and the azote gas remains alone.

33. Water, which does not dissolve nitrous gas, or the oxide of azote, converts it, nevertheless, into acid when it contains air. This is the reason why it sometimes absorbs it in part, and then acquires a rough taste, with the property of reddening blue vegetable colours.

34. Some metallic oxides among the most greedy of oxygen decompose nitrous gas. In a course of time, they reduce it to the state of azote. Others, on the contrary, yield to it part of their oxygen, and, by converting it into an acid, form with it metallic nitrates.

35. Nitrous gas has no action on the carbonic and phosphoreous acids. It unites with
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the sulphuric acid, and strongly adheres to it, changing it into concrete or glacial acid, which is environed with an atmosphere that becomes ruddy in the air, and suffers the gas to disengage, while the acid itself is dissolved by the absorption of moisture. It is liquefied, and very easily fixed in concentrated nitric acid, which it then converts into nitrous acid, as we shall see in the following article.

36. From the properties of the nitric acid already explained, we may conclude, that no acid can be considered as a more valuable instrument of philosophical process than this, and the exact knowledge we possess of its nature, its principles, their proportion, their almost gaseous state, and their solid adherence, must render it of extreme utility in chemistry. They throw the strongest light on its use in a variety of arts. No substance has advanced the science more than this; no substance presents an instrument of analysis of greater value or certainty in its results. When we consider it likewise as a remedy, the medical art, which is entitled to expect such eminent services from modern chemistry, may use it in a great number of practical indications. It has already been employed with great success in disorders of the skin, and syphilitic affections, of which it may serve to resolve the theoretic curative problem. Few substances, in general, have so strong a claim to the attention of the chemist, the physician, and the philosopher, as the nitric acid, or de-

deserve to be studied, with greater attention, in all its several habitudes.

ARTICLE XI.

Concerning the Nitrous Acid.

1. IT was in this state, and under this form only, that the nitric acid was formerly known; in consequence of which the names of spirit of nitre and nitrous acid were indifferently given to it: but, since the establishment of the pneumatic doctrine and the methodical nomenclature, the nitrous and nitric acids have been carefully distinguished. The rules of this nomenclature already show, that the nitrous acid must have the same relation to the nitric, as the phosphoreous to the phosphoric, the sulphureous to the sulphuric acid, and that consequently it contains more of radical and less of oxygen, and is therefore less acid and less strong. But these general ideas are not sufficient: It is necessary to examine this acid more in detail, in order to ascertain its differences from the nitric acid.

2. The nitrous acid is formed whenever the oxide of azote or nitrous gas is dissolved in the nitric acid, whether that elastic fluid be passed immediately into the acid, and agitated together with it, or whether a lower stratum of the acid
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be slowly decomposed by a combustible matter plunged therein, so that the nitrous gas, which is disengaged, shall become in part fixed in the upper strata of the same acid. In this manner it is that very clear nitric acid, at the bottom of which a metal is thrown, which gradually dissolves and deprives it of a portion of its oxygen, assumes first a blue-greenish colour in the part which dissolves the disengaged oxide of azote.

3. From a similar cause it is that the nitric acid, exposed to light, becomes coloured and yellow, in proportion as it emits oxygen gas, because in this case, as well as in the foregoing, the oxide of azote, detained in the acid, colours and converts it into nitrous acid. The same thing happens when the nitric acid is heated, for a long time, in a retort; with this difference, however, that the oxide of azote, being disengaged by heat carries with it in vapour a portion of the nitric acid, which it saturates and converts to an orange colour.

4. It is easy to understand from these first data, that the nitrous acid being merely a solution of nitrous gas in the nitric acid, or this last acid, charged with nitrous gas, there must be many varieties of nitrous acid, according to the proportions of nitrous gas, which are united to the nitric acid, and that what is called nitrous gas is never a compound of a constant and uniform nature. It differs, therefore, in this respect, from the phosphoreous and sulphureous acids, which are constant and de-

terminate

terminate combinations of phosphorus and sulphur, with the phosphoric and sulphuric acids. There is, nevertheless, a term in the union of the nitric acid with the oxide of azote, a point of saturation beyond which the union cannot be carried, namely, that at which the nitric acid is converted into a red vapour, very difficult to be condensed, and dissolved in water. It appears that the proportions of azote and oxygen contained in this maximum of nitrous acid, are, as Lavoisier has shown, 25 of the former, and 75 of the latter, which approaches very nearly to the state of nitric acid, and containing, as we have seen, 20 of azote, and 80 of oxygen. Priestley has found that 100 parts of nitric acid of 1,4 of specific gravity, absorbed 90 parts of nitrous gas to become converted to the state of red nitrous vapour.

5. Notwithstanding these varieties, and this indeterminate state of the nitrous acid, this acid, nevertheless, presents a collection of properties which distinguishes it singularly from the nitric acid, and are characteristic of it. When very pure, and in its maximum of oxygenation, that is to say, at 0,75 of oxygen, it has the form of a visible gas of a deep red colour, holding water in solution, and very difficult to be condensed in that liquid. This vapour is much more volatile than the nitric acid, and when this last is distilled, the portion of nitrous gas, which it may contain, rises together with some nitric acid, and is separated in the form of ruddy

dy vapour, so as to leave the nitric acid in a state of purity.

6. The nitrous acid, and that vapour which is the last limit of this oxygenation, undergo no farther change on the part of light or caloric. Oxygen gas does not combine with it as it did with pure nitrous gas; and though this gas be passed through the red vapour, it is not converted into nitric acid; an effect which depends on the adherence of the nitrous oxide to the nitric acid. Hence it is, that this mixture of gas, consisting of the red vapour, and oxygen gas, admits a lighted candle to burn in it better than in common air. Nevertheless, liquid or solid oxygen, can unite with the oxide of azote constituting the nitrous acid, and convert it into the nitric acid, which takes place when the nitrous acid vapour is agitated with aërated water. The nitrous acid has the same habitude with the common air as with oxygen gas.

7. There is no attraction between the nitrous acid and azote, nor absorption of azote gas by this acid. We may even remark, on this occasion, that azote can never combine with the nitric acid, nor carry it to the state of nitrous acid. It is necessary that it should be in the state of oxide to unite with it, which effect is probably caused by its greater density in that state.

8. Most combustible bodies undergo the same changes from the nitrous acid as from the nitric acid. There is, nevertheless, a very notable

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ble difference between the action of the two acids; namely, that the former inflames most combustible bodies much better, and more speedily than the nitric acid does, and that, in order to succeed in those inflammations which are among the most interesting experiments of chemistry, it is necessary to use the nitric acid more or less in the nitrous state, or charged with nitrous gas. The cause of this phenomenon appears to depend not only on the state of rarefaction or division, which the nitrous gas produces in the nitric acid with which it is combined, but also on the circumstance that the nitrous gas, as has been shown in the preceding article, is more decomposable than the nitric acid, and more readily yields its oxygen, which is less adherent to the azote in consequence of the great quantity of caloric united, at the same time, to the nitrous oxide. It is, accordingly remarked, that, at the moment in which an acid, more or less nitrous, attacks combustible bodies, particularly heated carbon, phosphorus, fused sulphur, or the metals divided and hot which it is capable of inflaming, there is disengaged with great effervescence and ebullition, a considerable quantity of gas which consists entirely of azote gas, which accompanies a portion of nitrous vapour carried up, at the same time, into the atmosphere. For the same reason it is, that the nitrous acid decomposes phosphorated and sulphurated hydrogen, and

and precipitates the phosphorus and the sulphur.

9. It has already been observed, that the true nitrous acid, or nitric acid containing almost its own weight of nitrous gas, and thus carried to the state of ruddy nitrous vapour, is scarcely soluble in water. In process of time, however, it becomes liquefied with the production of heat; part of the oxide of azote is disengaged in nitrous gas. Water, in proportion as the solution of this acid takes place in it, passes through shades of blue-green, green, yellow, orange, and brown-red. If it be charged with air, the first portions of nitrous vapour which are condensed, become changed into nitric acid.

10. The metallic oxides are differently affected with the nitrous acid, according to their particular nature. The least oxidized among them unite with the portion of nitric acid which it contains, and drive off the nitrous gas. The most oxidized metals sometimes change it into nitric acid by supplying oxygen.

11. The carbonic and phosphoric acids are not easily separated from their bases by the nitrous acid, properly so called, or by the nitric vapour, on account of the difficulty with which itself unites with these bases. By long contact the portion of nitric acid which contains the nitrous acid, at length disengages these acids, and the oxide of azote, or nitrous gas, exhales at the same time.

12. The

12. The phosphoreous acid is converted into phosphoric acid by the nitrous acid, from which at the same time the nitrous gas is disengaged. The sulphuric acid also effects this disengagement by the heat it produces, and seizes the water which was united to the nitrous acid. The sulphureous acid is converted into sulphuric acid by the same acid, which parts with its nitrous gas.

13. The nitric acid dissolves, or rather absorbs very rapidly, the nitrous acid saturated with oxide or red nitrous vapour, and thus passes to the state of the nitrous acid, which is more coloured in proportion to the quantity of the absorption. A great number of different nitrous acids may be composed according to the dose of nitrous vapour combined with them. Most of the nitrous acids, coloured from the blue-green to the brown-red in the laboratories of chemistry, are merely mixtures of nitric acid, with more or less of nitrous acid, properly so called. Therefore when they are distilled, the nitrous vapour is disengaged, and pale nitric acid remains in the retort. From the quantity of this last, a judgment may be formed of the kind of nitrous acid submitted to analysis. It must be observed, that as these coloured acids suffer the nitrous and ruddy vapour which coloured them, to fly off by heat, which being more volatile than the nitric acid soon fills the receiver, so likewise the nitric acid redissolves this vapour in cooling. For this reason

son it is, that when the nitric acid is prepared by rectifying the coloured acids of nitre, it is necessary to detach the receivers charged with this vapour; for if they be suffered to retain their communication with the retort, these receivers are found, some hours after the cooling, to be deprived of their colour, and the acid which had become pale by the heat, has resumed its red or orange colour.

14. The history of the nitrous acid throws a great light on that of the nitric acid, and nitrous gas. Though the nitrous vapour, which is the pure nitrous acid, is seldom used, yet the nitric acids, more or less nitrous, are often applied in chemistry, which produce in general, upon combustible bodies, a more speedy and energetic effect than the pure nitric acid, the reason of which has already been explained.

ARTICLE XII.

Concerning the Metallic Acids.

1. I SHALL not in this place speak of the metallic acids to a greater extent than is necessary to give a more complete and uninterrupted continuation of the account of these bodies, which are well-known compounds, formed by the union of simple radicals and oxygen. The particular properties of each species

cies of these acids will be more fully described in the section appropriated to the detailed history of metallic substances. It is therefore chiefly with a view to compare them in a general manner with acids already treated of, that I examine them here.

2. Out of twenty-one species of metals at present known, there are only four which can be converted into acids, namely, arsenic, tungsten, molybdena, and chrome. Though some others, in their last degree of oxidation, present certain properties similar to those of acids, yet these analogies are still too remote, and the differences between their state and that of other acids, too striking to admit of classing them among those compounds.

3. Like the preceding acids, formed of simple or undecomposed radicals, these acids also require a certain proportion of oxygen to arrive at the acid state. All of them, before their acidification, pass to the preliminary state of oxides. All of them, therefore, contain two portions of oxygen; the one simply oxidizing, and the other acidifying. In each of them the first of these portions adheres more strongly than the second.

4. Hence it arises, that during their acidification they first stop at the state of oxides, and frequently do not arrive at the acid state, but by processes very different from those which produce their oxides only. An inverted process is observable in their decomposition or disoxygenation,

difoxigenation, by treating them in a temperature more or less elevated, which is always necessary for that purpose, together with bodies which have more attraction for oxygen than the metals. They first yield their acidifying portion, and more strongly resist the separation of their oxidizing portion.

5. A strong light produces a commencement of decomposition in some of them, by disengaging oxygen gas. Caloric has much less power in decomposing them. As they all possess the form of fixed powders, they are rather disposed to vitrification.

6. They are unchangeable by oxygen gas, azote gas, and atmospheric air. Some of them are deliquescent.

7. All combustible bodies are capable of decomposing them, and in every case of seizing the acidifying portion, and frequently the oxidizing portion of their oxygen. This decomposition most commonly requires a large quantity of accumulated caloric. It is the more easy in that case, because most of these combustible bodies act by double attraction upon the metallic acids: in fact, one portion attracts the oxygen, while another portion is attracted by the metal. Combustible bodies, combined by two together, act still more speedily, and frequently at the first contact, and even without heat, upon these acids. Thus it is, that sulphurated hydrogen, or hydro-sulphurated water, blacken, and tend to reduce to the metallic

tallic state, or into sulphurets, the acids formed by the metals.

8. Several metals among those which are not acidifiable, are capable of decomposing the acids here treated of. It is a proof that the acidifying portion of their oxygen adheres less strongly than the oxidizing portion, that these metals which disacidify them, are frequently unable to difoxide them.

9. The metallic acids in general are much less soluble in water than the other acids. When dissolved, they communicate their acrid, rough, and metallic taste. They are easily separated by the action of fire.

10. They unite, more or less easily, with most of the metallic oxides, which are highly charged with oxygen. In this state of combination they constitute a great number of minerals, from which the art of chemistry separates them by means of many of the preceding acids.

11. They do not unite but with difficulty, or scarcely at all, with the greater number of these acids. When not completely acidified, they take from the nitric acid in particular a portion of its oxygen. This acid is most commonly used with advantage to convert the oxides of these metals into an acid state.

12. Besides the analogies which have been shown between the metallic acids and those before examined, another still more striking analogy is known in one of the former, and perhaps it

it may also be observable in most of the three others. Between its state of oxide and that of acid, in which it has only been yet known, I distinguish in arsenic, a modification manifestly acid, which appears to be to the arsenical acid that which the phosphoreous, sulphureous, and nitrous acids are to the phosphoric, sulphuric, and nitric acids. I shall describe the state in the particular history of the metal.

ARTICLE XIII.

Concerning the Muriatic Acid.

1. After the acids already examined, of which the nature of the radical and the proportion of principles are well known, we must place the muriatic acid; concerning which we have not acquired so much information; which has not yet been decomposed or composed; but which approaches many of the preceding acids in its properties and attractions; so that according to every method of arrangement, it cannot but be classed along with them.

2. The name muriatic acid is taken from the substance which most plentifully affords it, sea salt, marine salt, and salt water; *muria* of the Latins: *muyre*, of the ancient French. This name, taken from its origin, is given to it, because its radical has not yet been

been discovered in nature. Before the establishment of the methodical nomenclature, it was called spirit of salt, marine acid, acid of salt: and chemists, who wrote in Latin, had also given it the name of *acidum muriaticum*, which is merely translated in the French Nomenclature.

3. The muriatic acid exists abundantly in nature, and appears to be perpetually formed in the waters of the sea. Though we are almost witnesses of this formation, we are yet unacquainted with the principles employed by Nature, the proportion in which she combines them, and the mode itself according to which this combination is effected. It is always united to several of the salifiable bases, which will be examined in the next section. It is thought, nevertheless, to exist frequently pure, and in vapour, in the air which surrounds the sea, or in the sea water, agitated by the continual motion of the waves, and constantly in a state of evaporation. Some observations seem to give authority to this opinion, which is not, however, supported by any positive fact.

4. This acid is procured only by separating it from sea salt by means of the concentrated sulphuric acid, which has a stronger attraction for the base of the salt than the muriatic acid itself has. As this acid is very volatile, and easily reducible into gas, it is disengaged with a lively effervescence, and may be obtained, either in the form of an elastic fluid, or that of a liquid,

a liquid, when pure and cold water is presented to this gas, which absorbs and fixes it. Glauber, about the middle of the seventeenth century, first discovered this acid, and taught us to obtain it from sea salt; but since that early period the art of obtaining it has been greatly improved. It is only since the modern discoveries, and the chemical revolution of which I have spoken, that the accurate method of preparing it has been known. Before that fortunate period the greater part of this acid was lost in the air, as the details, to which we shall proceed, sufficiently prove. Though the muriatic acid is still one of the least known, we have acquired accurate notions respecting its attraction and properties, by the successive inquiries of a great number of chemists. It is particularly ascertained, that this acid has no connection with the sulphuric acid, either in its origin or its nature; which was thought to be its basis, at the commencement and even as late as the middle of the eighteenth century, nor with the phosphoric acid, which Stahl affirmed to be absolutely of the same nature. Though we do not yet know what it is, we have at least ascertained the means of determining what it is not, and thus overthrowing an error of long standing.

5. The muriatic acid, prepared or extracted by the method we shall describe, exists in two states, as I have before pointed out, either in the form of gas or of liquid; in this last state

it combined with water; under the first state, it is dissolved in caloric. We must attend to it under each of these conditions, beginning with the gas in which it exists most pure, and thence passing to the liquid state, which is more easily preserved, and in which it is most frequently employed in the operations of chemistry.

6. The gaseous muriatic acid differs little in appearance from the air of the atmosphere; nevertheless it is almost always slightly visible in the form of a vapour, on account of the water which it constantly retains in solution. Its specific gravity is twenty parts in the hundred greater than that of air; the cubic inch weighing 0,66 of a grain, whereas the air of the atmosphere weighs only 0,46. Its smell is strong, penetrating, acrid, acid, stimulating the eyes and the throat, and in a certain degree resembling the smell of the apple called the *rénet*, or that of saffron. Its taste is very sour and strong. It extinguishes lighted candles, giving to the flame a bright green colour, and stupifies and speedily destroys animals which respire it. It even acts upon the skin, which it reddens without corroding, burning, or even permanently colouring it like the sulphuric and nitric acids. It changes a great number of blue vegetable colours to red, and adds to the liveliness of those which already possess that tinge.

7. Muriatic acid gas refracts the light strongly, but is not altered by its contact. It is rarefied by caloric without changing its nature, however great the quantity may be which is accumulated. When this gas has passed through ignited tubes of porcelain, it undergoes no alteration but continues to exhibit the same properties as before.

8. It does not act in any manner upon oxygen gas, but may, nevertheless, absorb oxygen in the solid, or liquid state, as will hereafter be shown. When brought into contact with the atmospheric air, it immediately assumes the form of a white fume, dense, and heavy, at the same time that it emits heat round the point where it is condensed. This effect is owing to the water of the atmosphere which it condenses, and with which it combines.

9. It has no action on azote, hydrogen, carbon, phosphorus, sulphur, the diamond, and in general all combustible bodies. Charcoal, as a porous body, absorbs and condenses it, as do likewise sponges, cork, soft wood, &c. It is in consequence of this mutual inaction between combustible bodies and muriatic acid, that the nature of this acid has not been yet ascertained; for it is known that the decomposition, effected by this class of bodies, has afforded the means of determining the composition of the other acids.

10. Metals undergo no alteration on the part of the muriatic acid gas, excepting so far as

this gas holds water in solution. In this case, in consequence of the tendency of the acid itself to unite with the metallic oxides, and the predisposing attraction which it exercises, it favours the decomposition of the water by the metals, and combines with them after they are oxidized.

11. The muriatic acid gas has much attraction for water. When a small piece of ice is put into this gas, it melts immediately, becomes hot, and condenses the gas. It is evident, that all experiments with the muriatic acid gas must be made over mercury, because water will absorb it. If four parts of ice be fused with one part of muriatic acid gas, cold is produced during the fusion. This phenomenon is owing to the same cause which produces it with the sulphuric and the nitric acids. Liquid water speedily absorbs muriatic acid gas. It becomes heated in the same proportion: there are even 80 degrees of temperature produced in this experiment. At this period, the gas is no longer fixed, and its absorption cannot recommence until the temperature is sufficiently diminished. Water dissolves nearly its own weight of this gas, and becomes almost the double its original bulk. This combination is the liquid or common muriatic acid, the properties of which we shall speedily examine.

12. The metallic oxides absorb the muriatic acid gas, and form with it peculiar salts hereafter to be described.

13. Though

13. Though the muriatic acid possesses more strength than the carbonic, phosphoric, phosphoreous, and sulphureous acids, it does not expel these acids from their bases when it is in the form of gas, unless the combinations of those acids be dissolved in water, which begins by dissolving the gas, so that the decomposition is effected by the liquid acid.

14. The muriatic acid gas is speedily absorbed by the nitric, from which it seizes the acidifying portion of its oxygen, so as to reduce it to the state of the oxide of azote, but it does effect this dis-acidification of the nitric acid but in a limited manner, and until that acid is saturated with the oxide of azote which it contains. We shall, hereafter, treat of this combination which is usually made with the liquid acids.

15. Few of the operations of chemistry are made with the gaseous muriatic acid. It is much more convenient to employ this acid in the liquid state, or dissolved in water; whence it becomes necessary to compare this acid so liquefied to the same acid in the gaseous state. When water is charged with as much of the muriatic acid gas as it can dissolve, it forms a liquid of which the specific gravity, compared with that of water, is as 12 to 10. This acid is clear and colourless; it emits a white vapour, or fume, similar to that formed by mixture of the acid gas with the humid air, and its smell is the same.

16. The

16. The muriatic acid, for this is the term by which it is distinguished in the liquid state, is not altered by light. Caloric, when applied, disengages the gas. The last portion adheres with sufficient strength to resist separation with considerable force.

17. The muriatic acid absorbs neither oxygen nor azote gas. We shall soon observe, that it absorbs oxygen in the solid state, so as to become saturated. By exposure to the air, this acid emits the white fumes which result from its union with water, and which separates a sufficient quantity of caloric from the air, to produce a sensible heat in the hand when placed over a vessel full of this fuming acid at the moment of opening it.

18. The liquid muriatic acid has no more action on hydrogen, carbon, sulphur, and the diamond, than the acid gas itself. It dissolves such metals as are capable of decomposing water, which it renders still more susceptible of that operation; so that when it acts on a metal there is constantly a disengagement of hydrogen more or less pure.

19. It unites with water in all proportions and disengages a portion of caloric. It is weakened by this union, and soon ceases to emit fumes, because the adhering acid no longer tends to assume the form of gas with speed and energy.

20. It acts in a very different manner from the gas upon the metallic oxides. In general
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it dissolves them better than the other acids, and, on this account, it is used in laboratories to wash vessels soiled by these oxides. In proportion as it tends to unite with them, it separates from a great number of them, a portion of oxygen, with which part of the acid combines and forms the oxygenated muriatic acid, to be examined in the following article. The combinations of this liquid acid with the oxides, more or less charged with oxygen, are frequently volatile and fusible. They will be treated under the article of metals.

21. The muriatic acid expels the carbonic acid with effervescence, from its combinations; it is, likewise, stronger than phosphoric acid, in the humid way, to which it frequently yields its basis in the dry way. The sulphuric acid, possessing greater strength, separates it from its compounds, even from its union with water, but the muriatic acid expels the sulphureous acid from this liquid.

22. With regard to the nitric acid, one of the most decided and most remarkable properties of the muriatic acid, is its mode of action with that acid. These two bodies are scarcely brought into contact before they penetrate, become strongly heated, effervesce, exhibit a yellow or red colour, and form a mixed acid which answers a great many purposes not possible to be accomplished by either of the acids singly. This mixed acid was formerly denominated *aqua regia*, because it was found to be capable of dissolving

solving gold which was then called the king of metals. It is, at present, denominated the nitro-muriatic acid. It is not, however, a simple mixture of the two acids, as was thought before the establishment of the pneumatic doctrine. These two bodies, at the moment of their union, mutually act on each other by a double attraction, that of the muriatic acid for oxygen, and that of the nitrous acid for the nitrous gas, or the oxide of azote. Its effect enables the former to seize a portion of the oxygen of the latter, and that portion of the muriatic acid which is thus oxygenated, becomes disengaged with effervescence in yellow fumes. The undecomposed nitric acid absorbs the nitrous gas of its dis-acidified part, and when it is saturated the action ceases. This is the cause of the colour of the mixed acid, and, hence it is, that when the action is once terminated between them, the residue consists of muriatic acid mixed with nitrous acid, which it retains with considerable force. We shall, hereafter, see in what manner this singular mixture acts in the metallic solutions it produces. We must already deduce, that there would be no action between the muriatic acid, and the saturated nitrous acid; but that the nitrous vapour must be absorbed by this acid, and immediately form nitro-muriatic acid, or the *aqua regia* of the ancient chemists.

23. A most remarkable difference between the muriatic acid and all the preceding acids, truly consists in the absolute ignorance we are
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in respecting its intimate nature, on account of the well-known impossibility of its decomposition. We might, therefore, rank it among the undecomposed, or simple bodies, if by the rules of analogy, which must direct our opinions before they are fixed by experiment, we had not reason to infer that this acid is constituted like all the others. Many modern chemists have, therefore, presumed, that the muriatic acid is a compound of an unknown radical with oxygen; that this muriatic radical is, of all bodies, that which has the strongest attraction for the acidifying principle, and, on that account, no other combustible can seize this principle, or decompose the acid. But, it must be admitted, that though this conclusion is, in a certain degree, seductive, and presents a regularity of theory, it is, nevertheless, a pure hypothesis. It is true, that the absolute denial of the presence of oxygen, and its union with the combustible radical in this case, would also be an hypothesis. Hydrogen has been supposed to be the muriatic radical, and that this acid differs from water, which is the oxide only, by a greater proportion of oxygen; but this theory is very far from being yet proved.

24. The uses of the muriatic acid are very numerous; it possesses, as a medicine, the cathartic property when concentrated, and is cooling, antiseptic, and diuretic, when diluted with water. It is used to purify places infected by putrid vapours. A number of the arts, more particularly

ticularly those which relate to the metals, depend on the use of this acid. Its numerous applications will be regularly and gradually seen in all the articles which follow.

ARTICLE XIV.

Concerning the oxygenated Muriatic Acid.

1. THE muriatic acid differs also greatly from other acids, in the property it has of absorbing liquid, or solid oxygen, or rather the seizing it from a great number of combinations, than even by the impossibility of its decomposition. This property of becoming oxygenated seems to approach combustible bodies, and to show either that it does not itself contain oxygen, or that it is not saturated with that principle. This character of absorbing oxygen, and burning like a species of combustible, has induced some modern chemists to suppose that it may belong to another genus of acid bodies, different from the eleven other species.—That this new genus may comprehend acids not burned, not oxygenated, and void of the acidifying principle, that is to say, which do not depend upon this principle for their acidity. But this opinion, which is itself an hypothesis, does not impair the theory explained respecting the eleven

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ven former species of acids described in the preceding articles.

2. The oxigenated muriatic acid is a new acquisition for chemists. It was first discovered by Scheele, who named it the dephlogisticated marine acid. I afterwards proposed the expression of aërated muriatic acid, and the terms oxigenated acid, were afterwards adopted in the methodical nomenclature. Citizen Berthollet has added much to the discovery of Scheele, and thrown great light on the nature and properties of this acid. I have also myself made some additions to their last discoveries.

3. The oxigenated muriatic acid is no where found disengaged in nature: it is even doubtful whether it exists in a state of combination, though this is not impossible. It is prepared, or fabricated, by throwing the muriatic acid somewhat concentrated upon certain metallic oxides; or otherwise, by disengaging, by means of the sulphuric acid, the muriatic acid from marine salt previously mixed with one-fourth of its weight of oxide of manganese. I have discovered the same property of oxigenating the muriatic acid in several other metallic oxides, as I shall show in the particular history of the metals.

4. As soon as the muriatic acid comes into contact with the oxide, it forms a greenish-yellow vapour of a very acrid smell, which may be collected either in the form of gas, by causing it to pass speedily through a small volume
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of water, or in the form of liquid, by suffering it to remain long in contact with water cooled, and placed in a vessel of sufficient height, that its pressure may accelerate the absorption of the vapour. The properties of the gas, and that of the liquid oxygenated muriatic acid, must be successively described.

5. The oxygenated muriatic acid gas is distinguished from all the elastic fluids by its yellow-green colour, its suffocating odour, and its acrid and styptic taste. Its action on the nose and throat of those who respire it, is also one of its most remarkable characters.

It thickens the liquids of those organs in a manner which perfectly resembles what takes place in colds, and is followed by an abundant expectoration. It maintains the combustion of lighted candles, to the flame of which it gives a red colour, on account of the vapour of water formed, and environing it. Instead of reddening, it destroys many blue vegetable colours, and also discolours flowers, leaves, barks, and causes them to become white, frequently with a slight shade of yellow. We shall, hereafter, see, that on account of this property, it is successfully used in the bleaching of piece goods, &c.

6. Light and caloric do not cause any change in this gas: it may be passed through a red-hot tube without changing its nature.

7. It has no action upon oxygen, or azote gas, on which account, it mixes with the air without producing any change in its proper nature,

nature, only as it has much action on all the odorant vegetable and animal bodies, the putrid vapours, which affect the air in many places, must be destroyed by its mixture, on which account I have proposed it to destroy infection in prisons, hospitals, ships, &c.

8. It has no action on hydrogen gas in the cold, but in an ignited tube it burns it with detonation.

9. It inflames phosphorus, and changes it into very dry phosphoric acid: it also burns phosphorated hydrogen, and even renders gas of this kind inflammable, which is not so in the air.

10. Melted sulphur plunged in this gas takes fire, and affords sulphuric acid. It decomposes sulphurated hydrogen gas without inflammation, and precipitates the sulphur while the hydrogen is slowly burned. It even burns the sulphur of hydro-sulphuret dissolved in water, and, by this means, converts it into sulphuric acid in the midst of that cold liquid.

11. It has no action on carbon, either hot or cold, and favours its combustion so little, that when a mixture of equal volumes of carbonated hydrogen gas and oxigenated muriatic acid are mixed together, a combustion of the hydrogen takes place alone, and the carbon falls down. There is even a circumstance dependent on the proportion of the oxigenated muriatic acid gas added to the carbonated hydrogen, by which so far from burning the carbon, this addition converts

verts it together with the hydrogen into a true oil, as will elsewhere be shown.

12. It has no action upon the diamond in the cold ; but when this body, well ignited by fire, is thrown into the oxigenated muriatic acid gas, it takes fire, and affords carbonic acid gas according to Lampadius, professor of chemistry, at Prague.

13. The oxigenated muriatic acid gas burns all metallic substances, and even sets fire to some of them. This fact shows that flame is a property common to all combustible bodies, and depends only on certain conditions in the combustion. It is only required that these metals should be thrown in fine filings, or powder, into the oxigenated muriatic acid gas, in order that they may take fire instantly ; and the same observation is true of the metallic sulphurets and phosphurets. The metals thus burned by the oxigenated muriatic acid gas are more particularly those of which the oxides do not yield their oxygen to the muriatic acid. Though some of those which give out part of their oxygen to this acid, are capable of taking fire in the oxigenated muriatic acid gas, they do not become oxidized but in a very small degree. Under these circumstances, they are very far from being carried to the maximum of oxidation, necessary to render them capable of oxigenating the muriatic acid. This circumstance, like many other facts, also depends on the various attraction of the different portions of oxygen

igen for the metals, and for all combustible substances in general.

14. Water absorbs and condenses the oxigenated muriatic acid gas much less than it does of the ordinary muriatic acid gas. During its transition through this liquid, the oxigenated muriatic acid gas is in part dissolved, and becomes liquefied. Pressure and a low temperature is necessary to saturate the water. The history of the liquid oxigenated muriatic acid will be resumed in the succeeding pages.

15. Many metallic oxides absorb the oxigenated muriatic acid gas. None of the oxides refuse this absorption, but those which possess the maximum of oxygen. Very acid and very caustic metallic salts are thus formed, which will be hereafter described.

16. The carbonic acid, which is weaker than the oxigenated muriatic acid gas, is disengaged from its combinations by this gas, which takes its place, and gives to the former the gaseous form during its disengagement. It does not act upon phosphoric acid or its combinations. It burns a portion of the phosphoric acid contained in the phosphoreous acid, and converts it into phosphoric acid.

17. It produces no alteration in the sulphuric acid, which is much more powerful than itself; it burns the sulphur of the sulphureous acid, and changes it into sulphuric acid. Sulphureous acid gas passed into oxigenated muriatic acid

acid gas, forms a white very dense fume, which is precipitated in the form of sulphuric acid.

18. It does not alter the nitric acid in any respect, nor the nitrous acid, which it should seem, nevertheless, it ought to convert into nitric acid, because it changes nitrous gas into red vapour. In order to form a right notion of these two effects apparently contradictory, we must recollect, that oxygen gas, which reddens and condenses nitrous gas, has no action on the nitrous vapour; that oxygen gas never changes nitrous gas into nitrous acid, but merely into the ruddy nitrous vapour; that is to say, into nitric acid, saturated with nitrous gas; and that having thus converted a portion of the nitrous gas into nitric acid, which dissolves the whole remaining mass of this last gas, and forms a red vapour; the oxygen gas is not capable of producing any farther alteration. We may also explain this phenomenon in a single word, by observing that nitrous gas has more attraction for nitric acid than for oxygen. The oxygenated muriatic acid gas acts, therefore, in the same manner as oxygen, whether with the nitrous gas or nitrous acid.

19. Oxygenated muriatic acid gas is driven from water, and its combinations by the muriatic acid gas, on which account it frequently happens in the operations, in which a number of bottles of Wolfe's apparatus are used for the distillation of the muriatic acid absorbed by water in these bottles; that the first, which assumes

assumes a yellowish colour by receiving a small portion of the oxigenated muriatic acid (formed at the expence of a slight portion of oxide of iron contained in the marine acid), becomes white when the pure muriatic acid approaches, and drives off the oxigenated muriatic acid; which last frequently passes into the water of the second bottle, and colours it. This is an effect hitherto unexplained by any chemist, though it is frequently observed in the decomposition of marine salt by the sulphuric acid in the apparatus of Wolfe.

20. The uses of the oxigenated muriatic acid gas, are only relative to chemical researches, and some experiments of inquiry in our laboratories. It occupies too much space, and its action is too weak upon cold bodies, and at the same time too strong and disagreeable upon the organs of respiration, to admit of its being employed in the gaseous form in workshops or manufactories. It is most commonly used in the Arts, and even in Chemistry, in the liquid form, to which we shall immediately proceed.

21. We have already seen, that by receiving the oxigenated muriatic acid gas in proportion as it is formed into pure cold water, by means of a vessel sufficiently capacious and high to favor the absorption of the gas by its pressure, a liquid oxigenated muriatic acid is obtained. When this water is surrounded with ice, as is done in chemical laboratories, it not only be-

comes saturated with the gas, but the gas itself soon becoming saturated with water, crystallizes at the surface, and even at the bottom of the fluid, in the form of hexahedral plates of a brilliant greenish-white. This solid acid speedily loses its crystalline state, and quickly passes to the state of gas, when the bottle which contains it, beneath the saturated liquid, is exposed to a temperature somewhat higher than that of ice; so that in proportion as it is fused, it passes through the saturated liquid, in which it can be no longer fixed, and expands itself above in the form of a greenish-yellow gas.

22. The concentrated muriatic acid in the liquid state, or water saturated with the oxygenated muriatic acid gas, is scarcely more heavy than distilled water; its colour is greenish-yellow; its smell strong, acrid, and suffocating; its taste rough, sharp, astringent, immediately condensing the fluids of the mouth and throat, strongly attacking the nasal cavities, into which it may happen to be conveyed, and is not to be tasted without danger. It may be diluted with a large quantity of water, which weakens it, and leaves only a rough disagreeable taste, when it is applied to the tongue, or taken as medicine.

23. This acid does not redden the blue colours of turnsole, the violet, &c. but it immediately destroys them, as well as most other vegetable shades. There are only the yellow, which it does not attack in this state of concentration.

centration. It at the same time alters the form and nature of the vegetable texture, as well as those of the organs of animals, on the colour of which it has less influence than upon that of plants. It cannot, therefore, be used of this strength either for bleaching or as a medicine, except in some cases of external disease.

24. When exposed to the light of the solar rays, this acid is decomposed, loses its colour, suffers oxygen gas to escape, and passes again to the state of muriatic acid, and in this manner affords about a fifth part of its volume, or the sixth of the weight of the acid contained in the water, of oxygen gas. We have seen that when it is of a gaseous form, light does not decompose it in the same manner; heat disengages the acid in the form of gas, without decomposing it, or occasioning any perceptible separation of oxygen gas.

25. It does not combine with oxygen gas, nor with azote, nor their bases, at any temperature, or in any manner in which they can be presented to each other. In the air it loses little of its acid, which nevertheless escapes, though very slowly, emitting for a long time an insupportable foetid odour.

26. The oxigenated muriatic acid exerts no action upon hydrogen gas; it burns hydrogen in many of its combinations; it burns phosphorus alone, if its action be assisted by that of light, in which manner the phosphoric acid may be prepared, but then it is extremely weak, and

diluted with water, on account of the sparing solubility of the oxygenated muriatic acid. It decomposes phosphorated hydrogen gas, of which it burns the hydrogen, affording a white fume without flame, from which the phosphorus falls down without taking fire. It does not perceptibly act upon sulphur in fragments, or in powder; but it changes it into sulphuric acid when the sulphur is very much divided and dissolved in water, as, for example, in the sulphureous waters. It completely burns both the principles of sulphurated hydrogen gas; the oxygenated muriatic acid gas alone precipitates the sulphur. It does not burn carbon, but it rather separates and precipitates it from its combinations, by burning the hydrogen. It does not act upon carbonated hydrogen gas, nor upon the diamond.

27. It acts upon all the metals; none of them resists the influence of the oxygen it contains, which tends to be separated with ease. This is the reason why it oxides and dissolves gold and even platina, a metal so difficult to be oxidized, as I shall elsewhere show. It forms with them salts, either soluble or insoluble, which are simple muriates, because its oxygen previously combines with the metals.

28. It unites easily with water, which only dilutes and weakens it, without changing its nature or properties, but simply diminishes its energies and the promptitude of its effects.

Hence

Hence it is, that it is diluted with water in most manufactories and for medical use.

29. It unites with a great number of metallic oxides; sometimes it dissolves and renders them volatile, but in other instances it does not. Some are so highly oxidized, that they undergo no alteration by this treatment. Such in general are those oxides which convert the muriatic acid into oxigenated muriatic acid gas. Those of the oxides with which it combines, form different saline combinations of the muriatic acid, which are known by the name of super-oxigenated metallic muriates. We shall treat this object at length in the history of the metals which are capable of forming these combinations.

30. The oxigenated muriatic acid in the liquid state, does not expel the carbonic acid from its saline combinations, as the oxigenated muriatic acid gas does. It is much weaker than the phosphoric acid, and converts the latter into phosphoreous acid. In all its attractions it gives place to the fulphuric acid. As it changes the fulphureous acid into the fulphuric, it whitens and discolours the latter, when of a black colour, in the same manner as the nitric acid does. The fulphureous acid gas, when brought near the oxigenated muriatic acid, forms an abundant white fume, which has no smell, and is merely fulphuric acid. It does not act upon the nitric acid, nor the nitrous acid in red vapours. It decomposes ni-

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trous gas, and converts it to the state of nitrous vapours and ruddy acid. It mixes with common muriatic acid, to which it communicates its properties. When brought into contact with other oxigenated muriatic acid gas, it absorbs it, between the temperatures of 2 and 4 degrees above 0; and by yielding to it a small portion of its water, causes it to crystallize.

31. All the properties of the oxigenated muriatic acid, whether gaseous or liquid, prove that, in this singular combination with oxygen, the acid retains it weakly; that it tends to separate speedily by the least change of equilibrium in the attractions, and consequently, that it is capable of producing with celerity, those effects which are operated more slowly, and with particular circumstances, by the oxygen gas or by atmospheric air itself. It is a kind of agent which frequently represents, as well with regard to chemists as manufacturers, the air itself contained in a small volume;—with which they can produce in bodies, rapid changes of the same nature with those which the atmosphere would produce more slowly.

32. The uses of this acid began to be very numerous in manufactories, for bleaching a number of vegetable substances, and more especially different fabrics, old paper, soiled prints, ancient books, to take out writing, &c. We shall speak of those objects in a great number of articles in chemistry. It has become an important re-agent, since its nature or manner

of acting has been known. Great advantages have already been obtained from it in medicine; and I will venture to affirm, that it will hereafter be one of the most useful of the *materia medica*. It is known that it is strongly tonic, according to the doctrine of Browne; that it augments the force of the stomach and the whole system, and acts even as a specific in syphilitic disorders; that it discolours the urine and excrements of those that use it; that it bleaches the skin of negroes, &c. It is a substance of which we have begun to make trial of the medicinal action, and of which the mode of operation may lead to the most important discoveries respecting the animal physiology.

ARTICLE IV.

Concerning the Fluoric Acid.

1. THE fluoric is the second acid of which the intimate nature or composition is unknown. Its name is derived from the natural substance or species of stony salt from which it is obtained, and which has long been known by the name of fluor spar. It was for a certain time very improperly termed the sparry acid. The new denomination is generally adopted in all modern works and languages. This acid is very naturally arranged after the muriatic acid,

acid, with which it possesses some analogies that have long caused it to be confounded with that acid by various chemists. It immediately follows that acid in the order of its elective attractions.

2. This acid was discovered by Scheele, in 1771, and was much examined by Priestley in the state of gas. All chemists have since verified the experiments of these two celebrated men, and admit the specific character of the fluoric acid. Some have been since desirous of proving that this acid is either the muriatic or the sulphuric; but their experiments, from their uncertainty and inaccuracy when compared with those of Scheele, have convinced no one. That chemist himself replied victoriously to the objections made respecting the existence of fluor acid as a peculiar acid; and many learned men have since applied the specific properties of this new acid to the processes of the arts.

3. The fluoric acid exists in Nature, but never uncombined. It is always united with certain earthy matters, more especially lime, as we shall elsewhere show. It is obtained from this natural combination, from which it is extracted by the application of stronger acids. As its intimate composition is not known, it cannot be formed by combination. The process for obtaining it, consists in pulverizing its calcareous combination, placing the powder in a retort of tin or lead, upon which
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concentrated, sulphuric, nitric, or muriatic acid is to be poured. Distillation is then made, by adapting to the retort a tube of lead, which carries the gaseous acid under glass vessels filled with mercury, or a small receiver of glass, in which water is put to the half of its capacity. In the first case the fluoric acid gas is collected almost without heat, or by a very gentle heat; in the second, the liquid fluoric acid is obtained. We shall successively speak of the properties of this acid in its two states.

4. The fluoric acid gas is invisible, like air; but if it meet with a small portion of moisture, it is more or less cloudy or vaporous. Its smell is sharp, acrid, and considerably resembles that of the muriatic acid, though it cannot be said to be exactly the same. It is much heavier than common air; its specific gravity has not been exactly ascertained, probably, because it is never pure. It extinguishes a lighted taper, giving a very perceptible green colour to the flame. It destroys the life of animals, and reddens blue vegetable colours. Its most distinctive character is, that it corrodes, unpolishes, and dissolves glass; so that the thickest vessels of this substance cannot long retain it. It is very seldom exempt from the earth which forms the base of glass, even in the case when it is prepared in vessels of metal, because the substance from which it is obtained frequently affords the earth which it contains.

5. Light

5. Light is refracted by the gaseous fluoric acid in proportion to its density. Caloric dissolves it without appearing to alter its nature; for it passes, with all its properties, through an ignited tube of porcelain.

6. When brought into contact with oxygen gas, atmospheric air, or azote, it changes none of the properties of those bodies; neither absorbing them, nor appearing to be subject itself to any alteration. But when those fluids contain water, it absorbs that compound, and forms a dense white vapour, owing not only to the condensation of the acid by the water, but likewise by the precipitation of the earth it contains by the union of this liquid. Whenever, therefore, this gas is received in the air, it affords a very dense and heavy fume, which falls down, and is deposited in the form of white moist vapour on the surface of bodies.

7. Hydrogen, carbon, phosphorus, sulphur, and the diamond, as well as the hydrogenated, carbonated, phosphorated, and sulphurated gases are perfectly unchangeable by fluoric acid gas, which itself likewise undergoes no kind of change from their action. As we have seen that most of the other acids are decomposed by one or more of these combustible bodies, and that it is by such decomposition, that the nature of these acids has been discovered, the perfect unchangeableness of the fluoric acid by the same bodies, has not permitted us to ascertain its composition. This shows, either that the present
acid

acid is a simple body, which has no more proof with respect to this, than with regard to the muriatic acid; though the state of our knowledge, scarcely permits any such conclusion: or otherwise, which is the most natural at least by the force of analogy, that this acid has, for its radical, a substance of which the attraction for oxygen is stronger than that of any of the known combustible bodies. This last assertion, nevertheless, is truly an hypothesis as well as the former, though it is more agreeable to the known facts.

8. No metal acts upon the fluoric acid gas, or receives any alteration from it. All the metals have the same habitude with it as the other combustible bodies; so that they undergo no change, or oxidation, and consequently no solution if this gas be perfectly dry. But it is very greedy of water; if it contain a small portion of this fluid, it then speedily shows traces of oxidation in those metals which are most susceptible of that process, and are plunged in it.

9. Water, whether in the form of ice, or in the liquid state, easily absorbs the fluoric acid gas; which fuses ice, and cools it by producing the liquid state, or heats fluid water, by condensing it. In proportion as it becomes thus liquefied, it deposits most of the earthy matters it held in solution in its elastic fluid state, and when it is received from the bottom of the water so as to rise to its surface, it precipitates long cylindric

cylindric hollow portions of earth, which, arranging themselves in some instances beside each other, resemble the pipes of an organ. If it touch the surface only of the water it forms a solid crust, which breaks and falls down. By the same mechanism, a kind of earthy envelop, or stony clothing, as it has been called, may be deposited on the surface of fishes, frogs, and other aquatic animals which are plunged in it when wet, but which it kills before it thus covers. This effect has been compared to a petrification, and suspicions have been entertained that the last process may take place in the earth by a similar chemical mechanism.

10. The fluoric acid gas is slowly absorbed by the metallic oxides; at least by most of them. If water be added to those two bodies in contact, a more speedy and easy combination takes place: peculiar metallic salts are formed, which will be pointed out in the section destined to the particular history of the metals.

11. The fluoric acid gas displaces carbonic acid from most of its combinations: being weaker than the sulphuric, the phosphoric, nitric, and muriatic, it does not separate them from their compounds, but, on the contrary, is separated from its combinations by these acids. It does not change the phosphoreous, sulphureous, and nitrous acids, though it is stronger than the two last which it disengages from their combinations; and it has no action on the nitrous oxide, or oxide of azote. It is weaker
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than some of the metallic acids, and stronger than many others. All these facts relative to its actions, like the similar facts with respect to the other acids, will be pointed out in the articles of salts.

12. The fluoric acid in a liquid state, or united to water, exhibits some properties different from those of the same acid in the state of gas. It is heavier than water, though we do not know the ratio of its specific gravity. Its taste is very rough and acrid, though never caustic, however concentrated it may be. It reddens blue vegetable colours, without giving them brilliancy like the muriatic. It corrodes glass, for which reason it must be kept in bottles lined with wax. It emits very little fume, though water may be highly charged with it. It dissolves less of the earth of the vessels, than the same acid in a state of gas.

13. Light produces no change in this acid. Caloric disengages it easily from water, and causes it to assume a gaseous form. Nevertheless, the last portions adhere so strongly, that it is difficult to cause them to lose the liquid state, and to separate them from the water in order to give them the elastic fluidity.

14. This liquid undergoes no more alteration than its acid gas by the application of combustible bodies, which also undergo no change. It attacks the metals much more effectually than the same acid in the gaseous state. Its attraction for the oxides, renders water very decomposable

posable by many of those bodies; hydrogen gas is disengaged during its action. The acid dissolves the metals in proportion as they become burned by the oxygen of the water.

15. It unites with water in all proportions, and loses its force, in proportion to the quantity of this liquid that may be added. When its specific gravity is to water as 1,064 is to 1000, it retains no more than one 600th part of earth foreign to its nature, and is then as pure as it can be. It also combines with many metallic oxides, and does not act upon all the other non-metallic oxides. It does not assume any character of oxygenation like the muriatic acid.

16. The very slight effects dependent on the force, or weakness, of the fluoric acid, when compared with the other acids, are much more evident and sensible with the liquid acid, than in its state of gas. It is very worthy of notice, that it does not exhibit the same action on the nitric acid as the muriatic acid does; and that it is thus essentially distinguished from the latter. Though some chemists have affirmed, that it acts on nitric acid after the manner of the muriatic acid, this result has arisen from their fluoric acid not being pure, but containing a small portion of muriatic acid, as Scheele has proved in 1780.

17. Though the uses of fluoric acid are still very little extended, we may foresee that they will, hereafter, be of considerable importance

ance in the arts, from its property of taking off the polish and dissolving hard stones, and glass. It has already been proposed to engrave upon these substances in the same manner as is done with the nitric acid upon copper, and this new art has already been applied with success, in the fabrication of instruments of meteorology and natural philosophy.

ARTICLE XVI.

Concerning the Boracic Acid.

1. THE boracic acid is the third and last of those, of which the nature and composition are still unknown. Its name, like those of the two preceding, is taken from the salt from which it is extracted, generally known by the name of borax. The history of this salt will be given in the section of salts. The boracic acid was at first called sedative salt, afterwards acid of borax, or boracic acid. It received the denomination it now bears, at the time of publishing the methodical nomenclature in 1787.

2. The discovery of this acid dates in the year 1702. Homberg, a chemist of the academy of sciences at Paris, discovered and obtained it by the sublimation of a mixture of sulphate of iron and borax. He called it volatile narcotic salt of vitriol, or sedative salt, and was of opinion that the sulphate of iron, then denominat-
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ed vitriol, contributed to its formation. Leme-ry the younger soon afterwards found that it might be extracted from borax by the nitric and muriatic acids, always by sublimation. Geoffroy obtained it in the humid way by precipitation from the solution of borax, mixed with the same acids, and proved that it is united to soda in borax. Baron generalised this extraction by the weakest acids then known, and concluded, that this acid is ready formed and contained in the borax. Though some chemists have since supposed that the acids made use of contributed to form it, yet the numerous experiments which prove that it is perfectly identical whatever acid may have been used for its extraction, leave no doubt in this respect.

3. Though some facts seem to show that this acid is daily formed in fat matters, spontaneously decomposed, no accurate knowledge has yet been acquired respecting its formation. It is found dissolved in several lakes of Tuscany. It was first discovered in 1776 by Hoeffler, a chemist of that country, and the discovery was afterwards confirmed by several others. It is more particularly in the water of the lake Cherciago near Monterotondo, in the province of Sienna, that this acid exists in sufficient abundance to be advantageously converted into borax by soda. It is also combined in certain fossils with earthy substances, as will be shown in the section of salts.

4. To

4. To obtain boracic acid, which is simply extracted from borax, a sufficient quantity of sulphuric, nitric, or muriatic acid is poured into a hot solution of this salt, to give the fluid an excess of acidity. During the cooling, the boracic acid, separated by these last which are much stronger in their attraction, is deposited in the form of crystalline scales more or less large, white, and brilliant. These are washed on a filter with cold water, until all the marine acid has been carried off.

5. The boracic acid thus prepared, has the form of white micaceous plates, exhibiting almost the silvery brilliancy of the scales of fish, crystallized in irregular hexahedral flat leaves, of a cool and roughish saline taste, very light, and reddening blue vegetable colours. This acid is distinguished by its uses, its appearance, its taste, its form, and an unctuous, as well as brilliant appearance on its surface. It obstinately retains a small portion of the acid which serves to separate it from the borax.

6. The acid of borax is perfectly unalterable by light: when exposed to heat, it melts a short time before ignition, without any sensible loss of water. Its fusion is pasty, when the temperature is below the red heat; but, in the latter case, it flows very well, though not as fluid as borax itself. The boracic acid, thus fused, possesses the vitreous state, hard, transparent, and becomes slightly opaque in the air, without attracting humidity. It has undergone no alteration

ration; for when it is dissolved in hot water, it resumes its original form with all its properties, by cooling and crystallization. Nevertheless, Cartheuser has pretended, that by roasting and slowly calcining the boracic acid in an open vessel, taking care frequently to agitate it, an odour of muriatic acid is disengaged, and that by afterwards dissolving it in water a separation of earth takes place; so, that by repeated calcination and lixiviations, it may be decomposed into muriatic vapour and earthy powder. But this experiment on trial did not afford the expected result. It is also known, that the boracic acid, fused in the form of glass, and dissolved in water, assumes, at the bottom of the solution upon evaporation, a gelatinous form, and that of laminated crystals merely at the surface.

7. The concrete boracic acid undergoes no alteration by oxygen gas, common air, or azote gas, neither does it, in any respect, change the combustible bodies, hydrogen, carbon, phosphorus, sulphur, &c. from which it receives no known modification. The same observation also applies to the mixed hydrogenous gases, carbonated, sulphurated, gases, &c.

8. This, of all the acids, has the least action on the metals, and appears least capable of attacking them. As its taste and power of combination are extremely slight, in comparison with most of the preceding acids, we may form a notion why it favours not, without great difficulty,

culty, the decomposition of water by the metals which are usually the most disposed to that process.

9. It is, likewise, with the exception of the metallic acids, that which has the least attraction for water. Boiling water dissolves scarcely a fiftieth part of its weight, and cold water takes up much less, so that the acid crystallizes by cooling in the fluid. When it is evaporated in close vessels, or when a saturated solution of boracic acid is distilled, part of the acid rises with the water in the form of vapour, and crystallizes in the receiver. This sublimation ceases, when no more water is present, whence it follows, that boracic acid is volatilized only by favour of this fluid, being neither volatile nor sublimable alone, and, in fact, flowing into glass rather than evaporating. The solution of this acid has little taste, and reddens the tincture of turnsole very evidently.

10. There is little attraction between the concrete boracic acid, and most of the metallic oxides; whence they can scarcely be well united, but by means of the double elective attractions as we shall hereafter see. Water slightly favours this immediate combination. We shall, elsewhere, speak of this genus of metallic salts.

11. As this acid is weaker than most of the acids, we have seen that it is disengaged by them from its combinations; its attractions, nevertheless, compared with those of the other acids, vary according to the temperature, for in the

dry way, and particularly by ignition, it frequently expels from their compounds, acids which would separate it from its combinations in the cold, and by the humid way. It appears capable of undergoing some alteration still unknown on the part of sulphuric, the nitric, and the oxygenated muriatic acids, because, when heated with those acids, it deprives them of a portion of their oxygen, and partly disacidifies them. It appears capable of becoming itself oxygenated, but what befalls it in this state has not yet been determined.

12. The properties, indicated in the present article respecting boracic acid, proves that it differs from all the others. That which most strongly resembles it is the phosphoric, on account of its fixity and vitrifiability; but it possesses only, in a very weak degree, the property of mutual attraction, which is so remarkable and so powerful in almost all the preceding acids; it is nearly insipid, almost insoluble in water, and produces a very slight alteration in blue colours. It may be considered as the least powerful among the acids.

13. Without possessing a knowledge by any positive fact of the nature of the boracic acid, some modern chemists consider it, as well as the muriatic and fluoric acids, as a compound of an unknown radical and oxygen. They apprehend that its not having yet been decomposed, arises from its radical adhering to the acidifying principle with a force which no other body is capable

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ble of overcoming. Others suspect that this acid does not contain oxygen, but that with the two preceding acids, and some others hereafter to be mentioned, it constitutes a particular genus of acid bodies, not burned or oxygenated. These two opinions are simple hypotheses, equally unsupported by facts ; the first, after all the analogies which may be grounded on the actual state of chemical knowledge, appears, however, much more probable than the second.

14. The boracic acid is frequently employed in chemistry ; not as a re-agent, or instrument, to ascertain the nature of other bodies, for its attractions are too weak, and its action possesses too little energy to admit of its being applied to this use ; but in order to ascertain its proper combinations and the compounds to which it gives rise. It was long thought to be sedative or narcotic, and its first denomination arose from this opinion. But it is at present ascertained that it is not adapted to this indication. In the silversmiths and jewellers art, it may be used like borax itself to assist fusion, and cover the surface of small pieces of gold and silver which are soldered. Borax is, however, more advantageous, and deserves the preference also on account of its being more easy to be procured. The boracic acid is useful also to mineralogists, to favour the fusion of fragments of stone, which they treat with the blow-pipe. The manner in which it operates, the fusion or vitrification, the colours it assumes, and the form

form it affects, afford so many useful characters for ascertaining the classification of fossils. When the nature of this acid shall be known, it will render much greater services to the arts and contribute more to the progress of science.

15. I have lately heard, in Florio of the year seven, from Citizen Fabroni, a philosopher of Florence, that from his own particular experiments, he considers this acid as a modification of the muriatic; that it can be totally composed with that acid; and that the boracic acid is probably formed by this muriatic modification in the water of the lakes of Tuscany. But I am yet unacquainted with the facts upon which this opinion rests, and the experiments by which Citizen Fabroni thinks he has established it. I thought it proper to consign the fact in this place, on account of the confidence which the great intelligence and veracity of this skilful philosopher must naturally inspire.

SECTION FOURTH.

Concerning the Earthy, and Alkaline Salifiable Bases.

ARTICLE I.

Concerning the Salifiable Bases in general; their Classification, and that of the Earths in particular.

1. I CALL those bodies salifiable bases which, neither being combustible bodies nor burned substances, have the property of uniting more or less easily, and more or less strongly to these last, and of converting them into salts. The name of *bases* applies to them in general, because they fix, in some manner, the acids; because they take away, or annul, the volatility of the most evaporable, and, by this union, they mask, envelop, and destroy the acid characters, and determine, by their combination with these bodies, the species of the salts. The denomination of *salifiable*, employed first by Lavoisier, and which I have adopted after him, designates that when thus combined with the acids, they form

form the salts properly so called, and thence appear to constitute their essence.

2. The salifiable bases are of two kinds. Some of these are designated by the name of earths; others, by that of alkalis. I shall only treat, in this article, of the earths considered in general, or in the assemblage of their generic properties. The name of earth, given first to our globe, has been applied by chemists to a dry, insipid, acrid substance, infusible by heat, insoluble in water, which seems, by these characters, to represent the stability and inalterability of the globe itself, to belong most eminently to its formation, and to constitute a necessary part of its mass. Thus the word earth, by recalling the ideas of the terrestrial globe, indicates that every body of that name resembles the earth in its solidity, and in the permanence of the earth, that it partakes its properties, and appears to belong to it.

3. Chemists have a long time believed, that there is a primitive elementary earth, the origin and common source of all the others; forming the solid base of the whole globe, possessing a high degree of that character of inalterability and dryness which they attributed to the earth in general, and of which they thus admitted the existence in all the dry and insipid bodies, which more or less resemble it. They afterwards inquired to what peculiar matter they could most properly apply these properties; and, they believed, they had most eminently found them in
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that which was at first named vitrifiable, because it particularly possesses the quality of fusing into glass, by the assistance of alkalis : it is the earth of rock crystal, of flints, &c.

4. But in proportion as the art of analysis was improved, and extended to a greater number of fossils, and bodies more or less earthy, it was perceived that the number of earths increased; that several were met with very different from each other, claiming equally to be regarded as primitive. It was afterwards discovered that several had less insipidity, unalterability, and insolubility than others, and that there were some which, in taste and other properties, seemed to approach to alkaline matters.

5. It even appears that nature, in contradiction to the first conceptions of chemists, had determined by increasing their acquisitions and aggrandising their discoveries, to force them absolutely to reject the notion of a principle, or of an earthy element, by showing, on the one hand, that the pretended vitrifiable earth which they formerly qualified with this title of element, and which they regarded as the cause of the unalterability of a number of bodies, does not even exist in these bodies; but that it frequently enters, on the other hand, into the composition of matters, the properties of which, being very different from those which they attributed to it, did not even cause them to suspect its presence.

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6. The more progress the science made in the knowledge of minerals, the more the number of the earths became increased; and the more also the first hypotheses respecting a primitive earth, or an earthy element, must have lost their force, and their probability. Hence it results that our present notions concerning earthy matters, are very different from those which were formerly admitted; instead of regarding some earths as modifications of a pretended primitive earthy principle, we are contented to compare them all, to distinguish their differences, and to determine with care their distinctive properties; we are convinced they have only certain relations of quality, but not of nature, or of intimate composition; and, lastly, that being ignorant, of the difference, of the number, and of the proportion of the principles which constitute each of them, we ought rather to inquire into their attractions, and their specific characters, than to fabricate hypotheses respecting their origin, and their intimate analogies.

7. In the present state of our knowledge, I distinguish six species of earthy matters. Some chemists admit eight; but two of them are really alkalis, to which order of bodies, I refer them. There are also several others which were, at first, thought to be new earths, but which, soon afterwards, were discovered to be mixtures, or combinations of some of these earths with each other. It is by carefully analysing stone, by processes, and means unknown
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in ancient chemistry, that these important discoveries have been made. Of these very distinct and well-determined six earths, the ancients only distinguished two. The greater number of the four others are products of the labours of modern chemists, particularly Bergmann, Scheele, M. Klaproth, and Citizen Vauquelin.

8. Among the six earths well distinguished by their particular properties or specific characters, there are some which possess earthy characters in a more eminent degree; and others approximate to the alkaline substances. The first may be described by the term of *pure earths*, *arid earths*, or earths properly so called; and the second, by that of *alkaline earths*. These have frequently been named *salino-earthly* substances, *saline earths*, and *earthy alkalis*. It is with these last earths that the two species which I have referred to the alkalis properly so called, are classed by some of the moderns.

9. There are four pure, arid, insipid, or slightly sapid earths, slightly alterable by heat, insoluble, or almost insoluble, in water; in a word, earths properly so called. Of these four species, in a certain sense, the first are *silica*, *alumine*, *zirconia*, and *glucine*. There are two alkaline earths; that is to say, sapid like the alkalis, though never so acrid as they; turning several blue vegetable colours to green, and more or less soluble in water. These two species

cies have received the names of *magnesia* and *lime*.

10. The respective disposition of these fix earths in the order indicated, an order which will be followed in the successive examination of each of their species, commences with those which most eminently possess this earthy character, and leads to those which are most alkaline. As to these last, I have disposed them according to their force of general attraction for the acids: magnesia, as most weakly attracted by them; and lime, as most strongly attracted. This order is the inverse of that which I have adopted in the preceding sections; I have adopted it in order to establish a natural transition from the earths to the alkalis, gradually passing from the weakest as an alkali, and as it were the most earthy, which is flint, to the most alkaline, and consequently the least earthy, which is lime.

11. All these fix earthy matters exist in natural compounds, most frequently stony or saline, whence they are extracted by chemical art. None of them are yet known as to their principles or composition; and, though Nature appears to form them continually around us, and perhaps even with the proper materials of our bodies during our lives, we have not yet any notion of their principles, and we cannot produce the smallest quantity of any of them by art. It would appear then that I ought to
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place these substances in the sections of simple or undecomposed bodies; but every fact announces that they are not really simple beings; that we are on the point of obtaining their decomposition, and that they do not possess that order of simplicity which is remarked in these matters referred to in the second section of this work. Besides, it is natural and necessary to place the salifiable bases after the acids, since they have so much disposition to unite with the former, that they produce with them very important compounds, the properties of which it is necessary to examine immediately after theirs, and which become instruments of analysis.

ARTICLE II.

Concerning Silex.

1. SILEX, (in French *silice*, which name is derived from the word *silix*, and had long since been transferred from the Latin into the French language) has, at different periods, been denominated from its properties or its origin. It was formerly called the *vitriifiable earth*, because it eminently possesses the property of fusing into a transparent and solid glass, by the assistance of the fixed alkalis. That of quartzose earth has been substituted for this first name, because the principal genus of stones, wherein

wherein it is abundantly contained, was described under the generic name of quartz. The words *siliceous earth*, are yet the most frequently synonymous, as an adjective naturally derived from the word *silex*.

2. Silex, one of the most abundant of earths, forms the base of the hardest stones which appear to constitute the nucleus of the globe. For this reason it has been regarded as the primitive or elementary earth, and in some sort as the pre-eminent earth. It is found in rock crystal, quartz, silex, agates, jaspers, of which it forms the base, and in many other stones of which it forms one of the chief constituent parts in combination with other earths.

3. Nature never presents silex sufficiently pure for chemists to employ it as such in their operations; it is seldom pure enough to be used even in the processes of the arts. Some fine and almost purely quartzose sands, separated from foreign bodies which are mixed with the silex, by means of washing and the action of acids, may answer the purposes required in many manufactories, particularly in glass-houses and potteries. But the sand or siliceous earth most appropriated to the uses of these arts being merely fragments of quartz, of rock crystal rolled or worn down, and containing in their intimate composition a combination of silex and alumine, or even of other earthy substances, it is not in this substance such as it comes from the hands of Nature, that chemists
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can find pure filex; they are obliged to have recourse to different processes to purify it.

4. Before the analyses of the moderns, and principally of Scheele and of Mr. Klaproth, it was necessary to be contented with dividing and pulverizing the scintillant stones, quartz, and the purest filex, in order to procure this vitrifiable earth. These stones were ignited in the fire and plunged in cold water. After having thus caused them to crack in pieces by the sudden change of temperature, they are broken and crushed in mortars of agate or of filex, with a little water, and this powder is passed through sieves of silk, and then made use of as pure filex: but it is evident that it is only a pounded stone, and that the filex is far from possessing that state of purity which actual analysis demands. At present, it is by more complicated, but more certain processes, that filex is prepared for chemical uses. It is by fusion with the fixed alkalis, and separating it from its solvent by means of the acids which precipitate it, that pure filex is obtained. This process will again be treated of under the articles of the fixed alkalis.

5. Silex prepared by the processes here indicated, has the form of a very fine white powder, without taste or smell, the ultimate particles of which are rude and harsh to the touch. When it is rubbed between the fingers, it scratches and wears the epidermis, without adhering

adhering to it. When tasted, it is rough and dry on the tongue.

6. Light causes it to undergo no alteration. One of the principal characters of this earth is, that it is perfectly unalterable by heat, however great may be the quantity of that body, which is accumulated in it. It is regarded as the most incombustible substance in nature. It permits heat very easily to pass through its molecules, to penetrate it, and quickly to exhale; its capacity for this matter is very weak.

7. Silex has no attraction for oxygen, nor for azote; it does not attract them from any body, nor alter them in any of their properties, when it is exposed to the contact of oxygen and azote gas: hence it is not changed by the contact of the air; and does not attract any principle from it.

8. Neither has it any attraction for the simple combustible bodies; it has no action on hydrogen, carbon, phosphorus, sulphur, nor on the carbonated, phosphorated, and sulphurated hydrogenous gases. Less hard than the diamond, while its particles are combined in the stony aggregate, it can be worn and cut by that body. It acts mechanically on the metals in the same manner as the diamond acts on it. When it is rubbed on metallic surfaces, it scratches, wears, and furrows them; and if it be in very fine powder, the muriate, and very numerous scratches it makes on their surfaces,
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give them a very brilliant polish: for this reason it is used to clean and polish the metals. Exclusive of those mechanical and mutual actions, no attraction exists between silver, the diamond, and the metals.

9. Though it has been usual to suppose in the laboratories of chemistry, that water does not act on flint, which is true, when the particles not very small, and possessing some force of aggregation, this earth is nevertheless capable of contracting a strong adherence with water, provided it be extremely divided and attenuated, as it usually is in the fusions and solutions which it is made to undergo; it then forms, with liquid water, a transparent jelly; it is even totally dissolved in it, or at least it remains for a long time suspended in it, as I shall have occasion to remark hereafter. Nature certainly dissolves flint, even in great quantities, by processes which are yet unknown to us. It is thus that it forms in general the siliceous crystals, the stalactites, the incrustations, and depositions of the same nature; it is thus that according to the remark of Bergmann, the water of the boiling fountain of Geyser, in Iceland, after spouting to nearly thirty metres in the air, deposits in falling so great a quantity of siliceous earth, that it forms around its base in a sort of solid cup which surmounts and envelopes it. The adherence of water to flint, divided by the operations of chemistry, in which it assumes the form of jelly, is not annulled but by the strongest at-

tractions: thus we find that the siliceous jelly, much dried by long exposure to the air, loses 0,28 of its weight when it is exposed to the temperature which fuses silver.

10. Silex forms combinations with most of the metallic oxides. Some of them combine with it, or, at least, adhere to it more or less strongly, by the addition of a little water, and in the humid way: such is the theory of the solidity added to siliceous cements by the oxide of iron; others, and the greatest number, unite with it only in the dry way, and by fusion. Caloric, by favouring these combinations, exhibits the metallic oxides as the fluxes of silex. The result in general of these vitrifications are hard and coloured frits, or enamels; which will be treated in detail in the history of each metal in particular. I shall only observe here, that these vitreous and coloured combinations of metallic oxides and silex, employed in the arts of the glass maker and the enameller, always suppose the necessity of using alkaline fluxes; which announces that their fusibility, very weak in itself, requires the assistance of the fixed alkalis.

11. Insolubility in the acids was, some years ago, one of the most marked and distinctive characters of siliceous earth; but the science has acquired much on this point, since the art of analysing hard stones has become one of the most simple and most frequently exercised in the laboratories of the modern chemists. It was first discovered that the phosphoric and boracic

racic acids united with filex by fusion; it was then discovered that the fluoric acid, even in the state of gas, dissolved it, and communicated to it its invisibility under the aërial form. Lastly, the chemists experienced in treating the hard stones for examination and analysis, have remarked, that filex divided by the alkaline fluxes, remains suspended, and even frequently dissolved in the acids which were employed to precipitate it, and that it cannot be separated from them but by evaporating to dryness the liquors which held it suspended. It is principally in the muriatic acid that this dissolving property, with regard to filex, most sensibly appears. However, its combinations with the acids, if the fluoric be excepted, are of little permanency. When dissolved, or suspended in these fluids, it is easily separated from them by evaporation; their union is quickly annulled by the presence of caloric.

12. Though filex is never pure in natural products, yet as the uses to which it is particularly appropriated, either by nature, or in the arts, depend more particularly on the properties of this earth, and it not being possible to supply them by other earthy substances, it is under this article that what concerns these uses ought to be placed. In nature, the siliceous stones are manifestly destined to form the solid base of the globe, to constitute the primitive mountains, and to give them that durability which renders them permanent during the successive re-

volutions which the state of the earth undergoes. The places where siliceous earth is collected under the form of sand, present the character and effects of its dryness and insolubility. In the immense plains which it forms, the winds frequently transport it from one place to another, and accumulate moveable mountains. The waters continually wash it from the mountains into the vallies; the motion which they communicate to it wears and polishes its particles in such a manner, that they are at last rounded, and so glittering, that they have the appearance of a liquid. Perpetually carried to the lowest parts of the globe, siliceous earth forms the bottom of seas, rivers, rivulets, and brooks, and as it easily permits the water to pass which cannot act on it but with difficulty, it purifies, or rather clarifies, that liquid, the quality of which is so much more valuable, as it has remained a longer time on siliceous earths, or has passed through more extensive strata.

13. The uses of siliceous earth appear to be still more multiplied, and more varied in the arts than in nature. In the form of fine sand, the cultivator spreads it on the stony, or soft soil, to improve its hardness, or to dry its surface; it is also placed at the bottom of fountains, or of reservoirs of water to filter it, and deprive it of various foreign matters which render it turbid. The hardness of its particles cause it to be employed in the state of small sand, to clean, or scour metallic vases, and utensils. Mixed with

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a quantity of clay, by the founders of metals, it becomes one of the most useful materials of their art; to form the moulds in which the fused metals are cast into every possible form, from statues, cylinders, and flys the most voluminous, to cast nails of the smallest size, and most difficult to model. Silex also under the form of sand, of gravel, and of small pebbles, forms the base of the most durable and most solid mortars and cements; the fragments of which are united by pastes of lime and of clay. It is mixed in different proportions, under various forms, and in various states, in all the potteries of stoneware, of earthen ware, and of porcelain, to which it gives its own refractory qualities. Under this point of view, silix is one of the most important materials in chemistry. Lastly, this earth is also the true basis of the art of glass-making; since, on the one hand, it enters into the necessary fabrication of the furnaces and pots, and, on the other, it forms one of the first materials of glass, of which it determines the principal properties according to its nature, and its proportions.

14. Very pure silix exists only in the laboratories of chemistry, where it is used in the demonstrations and experiments on the different properties of bodies. In the hands of the chemist it sometimes becomes the proper subject of his labours, and sometimes the instrument of his researches. In the latter, it serves to determine the nature, or the characteristic properties of other

other substances, principally those of the fixed alkalis, of some acids, of several salts, as will be seen in detail in many of the following articles. It is equally useful in the docimastic treatment of some ores.

ARTICLE III.

Concerning Alumine.

1. ALUMINE derives its name from alum; it is derived from the Latin genitive *aluminis*; the reason of this denomination is founded on the consideration that this earth, which forms the base of the compound salt, named alum, *alumen*, is pure in this combination only, and from this alone can be extracted pure. It was formerly named argil, or argilaceous earth; but these names ought to be reserved for the natural earthy mixtures to which they belong, and which they ought exclusively to describe.

2. Alumine has been long confounded with calcareous earth in its saline combinations. Pott and Margraff are the first who distinguished it, and remarked that it does not afford any lime by calcination. Baron and Geoffroy compared it to a metallic earth. In 1739, Hellot positively determined that the base of alum, separated from that salt by an alkalis, is pure clay. Macquer, in 1758 and 1762, explained in several memoirs, inserted among those of the acade-

my of sciences, most of its distinctive and characteristic properties. Citizen Baumé, in a large work on clays, has affirmed, that this earth always contains sulphuric acid essential to its nature, and that there is a strong analogy between siliceous earth, clay, and the gypsum. These last notions were soon proved to be erroneous by the labours of Bergmann and of Scheele. Buffon considered clay as *flex attenuated*, and, as it were, rotted by the action of water, the air, and the sun. At present, all chemists acknowledge alumine to be a peculiar earth, and do not admit these forced analogies, and hypothetical conversions of one earth into another. They are convinced that these pretended transmutations have been founded either upon ill-performed, deceptive experiments, or inaccurate, or false observations.

3. Though alumine is found very frequently and abundantly in nature, it is never met with sufficiently pure to be used in the experiments of chemistry, and as it is impossible to bring native clays to the state of alumine, by any simple processes, it is better to extract it from alum, by decomposing that salt by the alkali. The base of alum, separated from sulphuric acid by the alkalis, is precipitated in the water which before held that salt in solution; it is then to be washed in a large quantity of pure, cold, and boiling water which must be agitated a long time with it to deprive it of all its salt; it is dried in the air, and is the pure alumine of the laboratories.

laboratories. It is very difficult to deprive it completely of the alkali.

4. Alumine, obtained by this process, has the form of friable fragments, or in a white, very fine powder, soft, and, as it were, unctuous under the finger, which feels worn by rubbing it; without definite taste; it sticks, or adheres closely to the tongue and organs of taste, which it dries and contracts, by attracting their fluids, and produces a slightly styptic effect. It is this which is named the earthy taste, because it is this which is most commonly produced by applying an earth to the mouth which contains enough of alumine in its composition to produce this taste very sensibly.

5. A peculiar odour is emitted from this earth when it is moistened, or when diffused in water; this odour is so striking that it is enough, in order to develop it, to blow or breathe the moist and warm air of the lungs upon dry alumine. It is the presence of alumine which gives this property to all the clays, to all the argillaceous earths of which the nature and character, though they may not be easily determined by other means, show themselves by this property in a manner which is seldom equivocal.

6. The purest flint which the sands present, is transparent and crystalline; alumine, on the contrary, appears to be opaque in its ultimate particles, and to communicate that property to stones, in which it enters in any notable quantity. Though some of these are transparent, their

their transparence is very different from that of siliceous stones. Alumine also gives to the earths, and even to the stones of which it forms a part, an arrangement, or texture in plates or small leaves applied to each other, as may be seen in the marles, the schisti and fuller's earth. It never assumes, by its simple aggregation, a degree of hardness like that of the siliceous stones; it does not possess, in the greater number of its natural combinations, the property of giving fire by the stroke of hard steel. The sapphire, in which M. Klaproth has found 0,98 of alumine, forms an exception to this rule by its excessive hardness and its beautiful transparence, and some calcedonies, as Citizen Vauquelin has observed, exhale an aluminous odour by trituration, without however containing alumine. A few exceptions do not, however, destroy a general rule.

7. Alumine is quite unchangeable by the contact of light, which it totally reflects. Caloric exercises a strong action upon alumine: when it is rapidly accumulated in great quantity, as with the flame of a candle, animated with oxygen gas, it becomes penetrated with light, softens, and melts without assuming the form of a globule. When cold, it presents an opaque frit; rough, or rarefied, like the horn of a stag, according to the expression of Lavoisier, of an obscure green colour, and sufficiently hard to mark glass. Burning-glasses do not produce the

the same effects. When alumine is exposed to the strong fire of a furnace, after being previously moistened, or reduced to a paste, it gradually loses the water it contained, contracts in its dimensions, dries, softens, and undergoes a semi-vitrification. When cold, it is found to have acquired a hardness and aggregation much stronger than before. It seems to have assumed the character of flint, since it becomes capable of giving fire with the steel; but its nature is not changed. This property of shrinking and hardening, which is termed baking, is the basis of the art of various potteries.

8. Oxygen and azote have no action upon alumine, neither does it, in any respect, act upon these two bodies in the state of gas, nor upon the atmospheric air from which it seizes only a small portion of water, when itself is very dry, and, in a course of time, it also takes up carbonic acid.

9. There is no known action between hydrogen and alumine. Hydrogen gas is neither absorbed nor altered by this earth. It has little action, and contracts no union with phosphorus. It does not unite with sulphur except when these two bodies are in contact, and minutely divided; as when the sulphate of alumine is decomposed by charcoal, and sulphuret of alumine is then formed, which may be immediately made by uniting sulphur and this earth, either in the dry or in the humid way. The remarkable properties of this sulphuret, which spontaneously
takes

takes fire by exposure to the air, and is called pyrophorus, when it contains pot-ash and carbon in a very divided state, will be explained in the history of the alum which is used to form it.

10. Carbon, the diamond, and the other metals, do not appear susceptible of uniting directly with alumine. We find, however, that carbon is combined with this earth in a considerable number of bituminous fossils. This natural compound comprehends the pit-coals, which are dry, not fusible, and do not afford oil by distillation, and which are carefully distinguished from the true pit-coal by their properties. They are not simple and pure combinations of alumine and carbon, for they also contain siliceous matter, iron, and other substances; they are called anthracites.

11. Alumine has much more attraction for the oxides and acids than siliceous matter: it exerts a very strong action upon water: when this earth is dry it rapidly absorbs liquid water, and suffers it to penetrate into its pores, until they are in a certain respect saturated. If more be added, the earth becomes soft, pasty, and ductile: in this state, it may be kneaded, moulded, turned, or fashioned into any desired form, which properties constitute the basis of all the arts of pottery. A portion of this water, which has been mixed with alumine to form the paste, escapes, and flies off in the air, the pieces which were at first soft, become dry and friable: if the drying be

be too rapid, the alumine cracks, splits, separates into leaves, or is divided into a kind of prisms analogous to basalt. In the baking of the pastes of clay, even when the fire is not urged beyond the temperature of ignition for silver, alumine loses 0,46 of its weight, whence it follows, that it contains near half its weight of water. For chemists know that this earth, even when long kept in a state of ignition, does not part with the least portion of earth but with great difficulty. The hardness it contracts by baking, may be attributed to the condensation of its parts, owing to the volatilization of the water, and even the commencement of vitrification which it undergoes.

12. When a paste of alumine, saturated with water, is put at the bottom of this liquid, it retains it and prevents it flowing through its pores. Such is the simple theory of the waters which are detained in subterraneous cavities, and afterwards flow out of the earth in the form of springs; and such also is the cause of the effect of clay in securing the bottoms of ponds, in which water is intended to be retained. Some chemists have thought that alumine was naturally soluble in water, and have admitted it as a principle in certain mineral waters. Bergmann, whose accuracy is well known, observes that the clay, which exists in waters, always renders them more or less turbid. It is consequently less soluble than flint. It never forms a jelly with water like this last earth, nor pre-
sents

sents native transparent crystals similar to those of flint.

13. Alumine is of all the earths that which has the strongest attraction for the metallic oxides. By a strong fire it melts with them into vitreous frits, more or less coloured; such are the coverings of some of the common potteries. In the humid way the union of alumine with the metallic oxides is made with so much facility, that remarkable and very durable combinations are thus obtained. Nature presents many of these compounds made by means of water: the ochres are all of this class. Art continually employs them, either in oil colours or in crayons, or in the art of dyeing, as will be shown hereafter. The attraction of alumine for the metallic oxides is such, that when once united with these bodies, even in the humid way, it defends them from the attractions of which they would be capable, more particularly from that of the unburning by light, or more advanced oxidation by the contact of air.

14. There is no acid with which alumine is not capable of uniting. It forms with them salts, some of which are soluble and crystallizable; most of them are insoluble, and several assume an excess of acid, though the degrees of attraction of this salifiable base for the several acids are yet but imperfectly known. It is nevertheless known, that the sulphuric acid adheres the most strongly of any; and that the nitric acid afterwards follows, and then the muriatic.

muriatic. With respect to the others, particularly the phosphoric and fluoric acids, their attraction for alumine is not exactly known. The boracic and carbonic acids combine the most difficultly, and adhere the least to it of any.

15. Alumine has a marked attraction for filex, and combines more or less with it by all the known processes. In the humid way these two earths contract an adherence which connects them together, and forms a kind of mortar capable of hardening and becoming little alterable by the air. The addition of the metallic oxides increases the hardness of these cements still more. It appears that the basis of the precious stones or gems in crystals, is a similar compound. In the dry way, alumine united to filex melts easily and forms an opaque glass. An elevated temperature, and such a proportion of the materials is required, that the alumine shall form at least half the compound. All the hard potteries are mere compounds of alumine and filex; of which the doses are so proportioned that the former does not predominate: without which condition the potteries, being more or less fusible, would assume in their baking the vitreous character which they are not required to have. By varying the proportions of these two substances, potteries of variable hardness are fabricated; more or less susceptible of vitrification and unchangeableness, and more or less capable of supporting sudden

sudden alterations of temperature, and resisting the action of a violent fire.

16. An attention to the study of alumine has singularly contributed to the advancement of chemistry, and the improvement of the chemical arts. It has been more particularly advantageous to the perfection of pottery; and the industrious Wedgwood is indebted to this kind of research for the improvements he has made in his manufacture of the different kinds of baked earths. This manufacturer, who was a skilful philosopher, has availed himself of the contraction of alumine during its baking, to construct a kind of pyrometer, or thermometer, which marks, with considerable exactness, the degrees of heat which the dilatation of liquids can no longer indicate, on account of the aëri-form state which the elevated temperature produces in such bodies. Several chemical vessels also depend on the use of alumine in the different mixtures of pottery for their perfection. The history of our knowledge acquired respecting alumine is, therefore, connected with that of the progress of the arts; from the Etruscans and the Chinese down to the fine French porcelains; as it is also to the progress of information from the ancient observation of the diminution of bulk in baked bricks, to the modern use of the pyrometric pieces of Wedgwood.

17. The uses of alumine may be considered with regard to its natural situations, and also to its applications in the arts. They are no less multiplied

multiplied in the processes of the former, than in the experiments of the latter. Alumine presides over a great number of natural phenomena. Formed, as it should appear, in the bosom of the ocean by a combination and mechanism which are equally unknown to philosophers;—deposited in horizontal, or inclined strata, or even in particular masses, it constitutes part of the mountains; it is sometimes found in the clefts of rocks; it most frequently composes the muddy soil of vallies, and humid low marshy plains: it is found at the bottom of lakes and springs. This substance prevents the filtration of subterraneous waters, and is the cause of those springs which issue from the surface of the globe, and the masses of water which fill its cavities. When mixed with a greater or less quantity of silex, lime, bitumen, sulphuret, and metallic oxides, when coloured with different shades, more or less fine, soft, ductile, dry, friable, foliated, it produces the fat earths, fullers' earth, boles, and other classes used in scouring, &c. The solid, compact, tenacious earths, which are commonly called arable soils, are in great part composed of this earth. It enters into the schisti, slates, steatites, asbesti, serpentines, and even the hardest gems. It is one of those materials which are most frequently employed by Nature in the formation of fossils.

18. Art, by imitating the processes of Nature, has singularly multiplied the uses of this earth. When pure, and extracted by chemical means,

it

it is only used in the laboratories of experiments for the composition of salts for earthy mixtures, and for the fabrication of the thermometric cylinders of Wedgwood. When more or less mixed, softened, purified, macerated in water, and ground, it forms the basis of all potteries from bricks and garden pots, to the most valuable porcelains. It is used to secure the bottoms of ponds and canals, in which water is intended to be retained and preserved. It is mixed with the lighter lean earths, to counteract the effects of too much sand and chalk, which injure their consistence, and prevent their retaining water sufficiently to support the vegetation of useful plants. This earth is used to colour and whiten stuffs, as well as to take out spots of grease, and it is one of the most useful ingredients in cements. When exposed to the vapour of burning sulphur it absorbs the sulphureous acid, and becomes converted into artificial alum, in the modern chemical manufactories. When strongly heated with various salts in a proper apparatus, it effects their decompositions, and separates their principles. When applied in a sufficiently diluted state upon glass, and various vessels, it forms a covering of lute which resists the fire, and defends them from its too strong, or sudden action. By kneading, or beating with boiled linseed oil, it becomes converted into fat lute, which is used to stop the junctures of earthen, or glass vessels. It is used to retain, or fasten the covers of crucibles

and to close or stop the cavities of the joints of furnaces, &c. It is also employed, with much advantage, in the construction of ovens, in large furnaces, in chemical workshops, and extemporaneous furnaces, of which the form and dimensions may be easily varied. Lastly, the same natural compounds, of which it constitutes a part, serve to give a fine edge to instruments of the first necessity, a softness, and smoothness which renders their use more convenient, and their action more moderate. Hence it may be concluded, that there is no substance more useful to society than alumine.

ARTICLE IV.

Concerning Zircon.

1. ZIRCON is named from one of the denominations of the jargon of Ceylon, a kind of crystallized stone resembling the diamond, which is found in this island, from which Mr. Klaproth, chemist, of Berlin, extracted this earth before the year 1793, the epocha of another similar discovery, which will be mentioned in one of the following articles. The remarkable properties which presented themselves to him in the analysis of the jargon, induced him to consider it as very different from every other earth. Soon afterwards, he found it in the oriental hyacinth.

Citizen

Citizen Guiton has extracted it from the hyacinths of the brook of Expailly, in France. Citizen Vauquelin has obtained it abundantly from that stone which was formerly placed in collections of the *Materia Medica*, to be used in some pharmaceutic compositions.

2. To extract zircon from these stones; after having pulverized them in a mortar of filex, and fused them in a crucible of silver, with five or six times their weight of pure pot-ash, the fused mass is treated with water, which dissolves the alkali without touching the zircon, mixed with filex, with which it was combined before the fusion. The remainder of this lixivium is afterwards dissolved by the muriatic acid, which is heated in order to separate the filex by spontaneous deposition, and from which the zircon is afterwards precipitated by caustic fixed alkali. When no further deposition is produced by heat, the precipitate, which is the pure zircon, is then well washed with water. It may also be obtained by decomposing by fire, the muriatic solution of zircon, made with the jargon, or hyacinth, fused with pot-ash, and lixiviated.

3. Zircon thus prepared, is a fine white powder, almost soft under the finger when rubbed; tasteless, and without smell. When it retains a certain quantity of water between its particles, it assumes the form of a semi-transparent jelly of a white colour resembling horn. This is merely a factitious, transient, and accidental disposition. The specific gravity of this earth,

when its particles are united again by aggregation amounts to 4300.

4. Light has no action upon zircon. Caloric causes it to undergo some change in peculiar circumstances only. Thus when heated with the blow-pipe, it remains infusible, and emits a phosphoric yellowish light; but when it is heated in a crucible of charcoal, bedded in charcoal powder, and placed in a crucible of earth, exposed to a good forge fire for some hours, it undergoes a pasty fusion, sufficient only to cause its particles to come together without losing their transparency, and without acquiring a truly vitreous form. In this state it is contracted, extremely hard, gives fire with the steel, has a slightly brilliant, vitreous fracture, or rather resembles porcelain in that respect, easily marking and cutting glass, and of a grey slate-colour to its centre. And, in this state, it has the specific gravity before mentioned.

5. Zircon has no attraction for oxygen, nor azote, neither does it act on the one or the other of these bodies in the state of gas, whether separately, or when they form atmospheric air by their mixture. It does not perceptibly act upon the water, nor carbonic acid of the air.

6. The action of zircon upon hydrogen, carbon, phosphorus, sulphur, the diamond, and the metals, is absolutely none; but when it is heated in the midst of charcoal, it retains a portion which adheres to its surface, and colours it. When rubbed on metals, it scratches and wears their

their surface on account of the hardness of its particles.

7. Zircon is insoluble in water, but it contracts a remarkable adherence with it like filix, and then forms a transparent jelly. When dried at the temperature of ignition of silver, that is to say, in a crucible of this metal made red-hot, it is found to lose 0,37 of its weight; consequently it retained, between its particles, more than one-third part of its weight of water; though when once dried in the pulverulent form, it becomes entirely insoluble. After ignition in a crucible in order to dry it strongly, zircon is found to have lost its whiteness, and to become grey and hard, crackling between the teeth, and is much less easily soluble in acids.

8. Though the action of this newly-discovered earth upon the metallic oxides is still little known, it has already been seen that it is similar to the action of filix, which it resembles in this property, as well as in several others.

9. It unites with all the acids, and forms with them salts which will be examined in the following section. We must here note, as general properties of its saline combinations, that the salts which it forms, with the sulphuric, phosphoric, and carbonic acids, are insoluble. The order of its affinities for the acids has not been exactly determined. It appears greatly to resemble that of alumine. It has already been observed that zircon, hardened in fire, or fused in charcoal, is much less, or not at all soluble in acids.

10. Notwith-

10. Notwithstanding the few researches which have yet been made respecting zircon, it has been discovered that it may be fused with flint, and even with alumine; and that a mixture of these three earths is still more susceptible of becoming soft before the blow-pipe, than any two taken together. We shall see that this is a general fact with regard to the mutual action of all the earths with each other.

11. The properties of zircon resemble flint in certain respects. The same hardness of particles is observable in both, the same insipidity, the same want of odour, the same insolubility in water, and the same tendency to adhere to that fluid, or retain it, in a very attenuated state. On the other hand zircon differs from it by its specific gravity, which is greater than that of flint, its imperfect fusibility in the midst of charcoal, its solubility in acids, which is so much greater than that of flint, that a solution of both earths in the muriatic acid, lets fall the flint by evaporation, and retains the zircon.

12. Another still more striking difference than the foregoing, is the manner in which zircon is acted upon by the alkalis. This difference serves, besides, to distinguish it from alumine. Being totally insoluble in the fixed alkalis, it differs greatly from flint in this respect, which is very soluble, and from alumine, which contracts a still more intimate union with these bodies than flint, as will be shown in
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the following articles in the details relative to these alkaline combinations.

13. The salts which it forms with the acids, establish still greater differences between flint, alumine, and zircon. Its attractions for these bodies likewise follow another order than those of the two former earthly bases. They afford characters sufficient to distinguish zircon from every other body, and it is in fact from the consideration of the whole of these properties that Mr. Klaproth has admitted it to be a peculiar earth. The whole of these considerations will be given in the section of salts.

14. Zircon has not yet been applied to any use. It will, no doubt, hereafter become useful either in chemical analyses, or the processes of the arts. But in that case we must first succeed in finding it in greater abundance, and also in the discovery of more simple and economical processes than any yet known, to extract it from the stony compounds in which it is contained.

ARTICLE V.

Concerning Glucine.

1. GLUCINE is a new earth, discovered during the winter of the year 6, of the French republic, by Citizen Vauquelin, first in the aqua
marine

marine or beryl, and afterwards in the emerald. The occasion of these discoveries was the exact and comparative analysis of these two stones, made with great care by that chemist, on the invitation of Citizen Haüy, who having discovered a perfect conformity between them, as to structure, hardness, and specific gravity; and suspecting that they might contain the same principles, desired that skilful chemist to ascertain the truth, by comparative analysis. We are, therefore, in a certain respect indebted to geometry for the origin of this discovery. That science afforded the first notion, and we may affirm, that without its co-operation, the knowledge of this new earth would not for a long time have been acquired, since, according to the analysis of the emerald, by Klaproth, and that of the beryl by Bindheim, the examination would not probably have been recommended, but in consequence of the strong analogy or identity nearly perfect, which Citizen Haüy found in the geometric properties of these two stony fossils.

2. The first notion of the existence and particular nature of glucine, occurred to Citizen Vauquelin from the manner in which this substance is changed by re-agents; its less effectual solution in pot-ash than that of alumine, with which it was confounded by Messrs. Bindheim and Klaproth, and even by Vauquelin himself. Observing that a portion of the supposed alumine, extracted from the beryl, presented results

sults different from those which that earth usually offers in its treatment, he examined this portion with much care, and ascertained by numerous experiments that it truly differs from alumine, which it resembles; and also from the other earths, which it resembles much less. No doubt could remain with him respecting these differences, and consequently its peculiar existence, because this earth treated with the acids, the alkalis, and the various salts, has constantly exhibited distinctive characters; and because he has found its attractions in particular to be very different from those of the other earths, especially from alumine, with which it was found mixed and confounded, in the analysis hitherto made of the beryl, the emerald, and probably even the other stones in which there is also reason to suspect its existence.

3. Among the specific and characteristic properties of this new earth, discovered by Citizen Vauquelin, that which has appeared the most capable of distinguishing it, being the saccharine taste which it gives to its combinations with the acids, we have concluded, in consequence of a discussion between Citizen Vauquelin, Guiton, Chaptal, and myself, respecting the name it ought to receive, that the word glucine, derived from the Greek words γλύκυσ sweet, γλυκὺ sweet wine, γλυκαινειν, to render sweet, is most appropriate. This determination appeared to us well calculated to assist the
memory

memory, by recalling that property in which it sensibly differs from all the other earths. We have supposed that without presenting notions falsely conclusive, as would have been the case if we had derived its name from the stone which afforded the first product, or the place whence it was obtained, it could not assume, in its etymology, a sense too strictly determinate, and that we should by this proceeding confine ourselves to principles of nomenclature, no less suited to advance the science than to facilitate its study.

4. As it is more particularly from the property of not forming alum with the sulphuric acid and pot-ash, as alumine does; and also by that of its solubility in the liquid carbonate of ammonia, which alumine does not possess, that Citizen Vauquelin has admitted glucine to be a particular earth, different from these last; he more particularly availed himself of these two processes to separate glucine from the other earths with which it is combined in the stones hitherto found to contain it. Accordingly he takes 100 parts of beryl or emerald, and reduces it to fine powder, in a mortar of flint. These are fused in a silver crucible, with 300 parts of caustic pot-ash; the fused mass is diffused in distilled water, and the whole dissolved in muriatic acid. The solution is then evaporated, taking care to stir it towards the end of the evaporation. The residue is in the next place mixed with a large quantity of water, and filtered;

filtered; in consequence of which the filix is separated and obtained apart. The filtered liquor, which contains the muriates of alumine and of glucine, is precipitated by the carbonate of pot-ash; this precipitate is well washed and dissolved in the sulphuric acid. To the solution is added a certain quantity of sulphate of pot-ash, and the crystallized alumine is obtained by evaporation. When by a new addition of sulphate of pot-ash and renewed evaporation, the fluid no longer affords alum; the solution of the carbonate of ammonia is to be added in excess, and the whole strongly shaken. The glucine after having fallen down, becomes dissolved by means of the excess of this salt, and the small quantity of alumine which might be mixed with it, remains precipitated without solution. After several hours, when it is found that by the new addition of carbonate of ammonia, and agitation, the aluminous precipitate suffers no further loss of its volume, the liquid is filtered, and boiled in a glass body or capsule of porcelain. In proportion as the carbonate evaporates, a white granulated powder falls down, which is the carbonate of glucine, and from which the carbonic acid is easily separated by slight ignition in a crucible. By this means the pure glucine is obtained, in the proportion of 15 or 16 per cent. of the beryl or emerald made use of. This process may be hereafter employed to ascertain the existence of glucine in other stones, in which it is probable that it accompanies

accompanies flint and alumine, and by that means to discover a method of procuring a greater quantity than that which Citizen Vauquelin has extracted from the two stony fossils here mentioned, which besides are very scarce and costly.

5. Glucine prepared by the foregoing process, has the form of a powder, or white fragments, light, soft under the touch, insipid and adhesive to the tongue. It is perfectly apyrous and infusible by fire, and neither shrinks nor hardens like alumine. Its specific gravity is not yet known, nor is it capable of changing blue vegetable colours.

6. Though the means of ascertaining its properties with accuracy have hitherto been few, it appears to follow from the experiments to which it has been subjected, that it is unchangeable by oxygen gas and azote gas; that it undergoes no alteration in the air, and does not perceptibly absorb moisture or carbonic acid.

7. We are not acquainted with any union between glucine, hydrogen, carbon, phosphorus, or sulphur. It is not capable of uniting with any combustible body but sulphurated hydrogen. When this body, in the state of gas, is passed into water in which glucine is suspended, the earth is dissolved, and forms an hydro-sulphuret, of which the properties are similar to those of many compounds of the same nature, which will be described in the following articles.

articles. We shall likewise observe, that when the fulphate of glucine is decomposed by carbon, a similar combination is obtained. This property of forming an hidro-fulphuret likewise constitutes a difference between this earth and the preceding, and assimilates it to the alkaline earths, which we shall examine in the following articles.

8. Glucine is insoluble in water, but it forms with this liquid in a small quantity, a paste slightly ductile, which is neither so smooth nor tenacious as that of alumine, and is not susceptible of induration by heat. Its action upon the metallic oxides, as well as that which it may have upon the burned bodies, is yet unknown.

9. It easily unites with all the acids, and forms with most of them soluble saccharine salts, slightly astringent, and difficultly crystallizable. Its attractions for these bodies appear to hold the following order: sulphuric acid, nitric acid, muriatic acid, phosphoric acid, fluoric acid, boracic acid, and carbonic acid. This is the order which most of the earthy bases follow which are susceptible of combining with these compounds.

10. The order of the attractions for the acids, compared with that of different earthy and alkaline bases, appears to be such, that it yields its place to all those bases, if we except alumine, zircone, and flint; so that its salts are decomposed by all the others, and it decomposes
only

only those which are formed by the acids with these three last earths. We must observe, that in order to obtain the salts of glucine in a state of purity, and to clear them from a small portion of oxide of iron or of chrome, which they often retain in consequence of the existence of these two metallic colouring matters in the beryl and the emerald, from which the glucine is extracted, Citizen Vauquelin has successfully used the alkaline hidro-fulphuret, a compound, which will be described hereafter, and which has the property of precipitating the metallic oxides without affecting the glucine. The hidro-fulphurated alkali must be well saturated, in order that it may not separate the earth, at the same time that it throws down one or the other of the oxides, which changes and colours the salts.

11. In order to characterise the glucine in a proper manner, and to prove its difference from all the other earthy substances, particularly alumine, I shall add, though I have not usually mentioned these properties under the articles of the bases, that the salts of this earth are precipitated by the nut-gall, but not by the oxalates, the tartrites, and the soluble prussiates, nor by the well-saturated hidro-fulphurets; whereas the aluminous salts are strongly precipitated by the latter; that the precipitate which they form with the alkalis, is totally soluble in the carbonate of ammonia, whereas that of every other earth is not.

12. Nothing

12. Nothing is yet known respecting the mutual re-action of this earth and the three preceding. It is not known, whether glucine acts as a flux to the other earths, nor whether those earths can act in that manner with the present.

13. Citizen Vauquelin, after having exhibited the preceding details, as well as several others, which will be given hereafter, respecting the combinations of glucine, presents as the specific characters of the earth, the six following properties, which are not found in any of the five other known earthy substances.

A. Formation of saccharine and slightly astringent salts with the acids.

B. Solubility in the sulphuric acid with slight excess.

C. Decomposition of the aluminous salts from which it separates the earth when it is boiled in their solutions.

D. Complete precipitation of its salts by ammonia.

E. Total solution by the liquid carbonate of ammonia.

F. Attraction for the acids holding the mean between magnesia, which separates it, and alumine, which it precipitates.

14. This earth has been known too short a time, and has yet been obtained in quantities too small for it to be applied to any useful purpose, or even for it to be possible to indicate such a purpose.

Citizen

Citizen Vauquelin thinks that when it shall hereafter be more abundantly obtained, it may be applied to many useful purposes in chemistry, the arts, and medicine; he thinks it probable it may serve as a mordant for dyeing like alumine, on account of the considerable attraction which it has already presented, in his experiments, for vegetable and animal colouring substances. The saccharine and lightly astringent taste of its saline combinations, leads him to suspect that it may possess certain salutary properties with regard to the animal economy, and that in this respect it may become one of the most agreeable medicines which can be used.

ARTICLE VI.

Concerning Magnesia.

1. THE name of magnesia, the first and the weakest of the alkaline earths, has long been adopted to denote a falsifiable base, which was originally confounded with others under the general name of absorbent earths. This word, evidently derived from the magnet, was no doubt given to denote certain imaginary virtues of this earth. Without using it for any purpose of this kind, the term has been continued to designate this earthy basis, and no attempt

attempt has even been made to substitute another. The terms muriatic earth have been proposed, because it abounds in the waters of the sea, but this name would have created confusion when applied at the same time to an acid, and a base. It has often been called the earth of Epsom salt, because it forms part of the salt long distinguished by that name.

2. A Roman canon was the first who sold this earth as a secret medicine, at the commencement of the eighteenth century, under the name of white magnesia, or powder of the Count of Palma. Valentini discovered in 1707, that this powder, boasted as a panacea, was the product of the mother water of calcined nitre. He called it the laxative polychrest powder. In 1709, Slevoght described the method of obtaining it by precipitation. Lancisi, and Frederic Hoffman afterwards spoke of it, the first in 1717, and the second in 1722. When it became more common in pharmacy, chemical physicians confounded it with calcareous, or absorbent earth, though Hoffman had already carefully distinguished them, by observing that this last forms an insipid and inert salt, with the sulphuric acid, whereas magnesia affords a very bitter purgative salt, with the same acid. Black was the first who, in 1755, explained, in an extensive and methodical manner, in the *Memoirs of the Edinburgh Society of Medicine*, the difference between magnesia and lime. Margraff, in 1759, published another memoir, in which he men-

tions various characters, by which this earth may be distinguished from every other. Macquer and Bucquet in France, insist much on the distinctive properties of magnesia, and its various combinations. Lastly, Bergmann in 1775, and Butini of Geneva, in 1779, published dissertations which have left nothing to be desired respecting this earthy base.

3. Magnesia has never been found pure in nature. It exists abundantly, but less however, as it should appear, than lime. It is combined, like that earth, either with other earths in the pot-stones, steatites, asbestos, mica, and schisti, which, on this account, have been named magnesian stones, or in combination with the carbonic, sulphuric, and muriatic acids, &c. in the waters of the sea, the salt springs, and other mineral water, and, in the mother water of nitre, and sea-salt. It particularly accompanies marine productions.

4. This earth is separated from the saline substances which contain it, by precipitation, by pure alkalis, lime, barytes, &c. as will be more fully observed under the article of salts. It has long been separated particularly from the sulphate of magnesia, called Epsom salt from the name of a spring in England, of which the water is impregnated with it. It may be obtained from all the salt waters in which nature has more or less abundantly placed the magnesian salts. After having precipitated it hot, and in much water, it is carefully washed in cold and in
hot

hot water to carry off the adhering salt. It is also prepared, though in a state of less purity, and never sufficiently pure for chemical uses, by strongly calcining some salts which contain it. Such was that which was sold under the name of white magnesia. It contains chalk and foreign saline substances. Notwithstanding the attentions of chemists, it is found mixed with a small quantity of flint and of lime. In the following section, we shall show how it may be obtained perfectly pure and exempt from every mixture.

5. Magnesia, in a very pure state, is usually in form of white masses, light, friable, and resembling starch, or in a very fine, white, impalpable powder. Its specific gravity is about 2,33 according to Kirwan. Its taste, which is very sensible, is somewhat sweetish, and produces a particular sensation which distinguishes it from every other substance; this taste is rather stronger on the stomach and intestines, where it operates as a weak purgative. It slightly converts the most delicate blue vegetable colour, such as the flowers of mallows to a green.

6. It undergoes no action on the part of light, and is very little heated by the contact of that substance, because it reflects it almost entirely under a white and considerably intense colour. When exposed to a violent fire, it does not melt according to Citizen Darcet. Macquer has observed, that it is equally infusible and unchangeable in the focus of the great lens of the academy.

demy. Citizen Guiton had the same result, when he kept it for two hours in the strongest heat of Macquer's furnace: he remarked, that it separated from the crucible, and contracted a little. By strong calcination, it became finer, more friable, and white. Citizen Butini has observed that it contracts a little. Mr. Parker exposed a cube of magnesia reduced into a paste with water to the focus of his burning lens, and observed it suddenly contract in all its dimensions; a property similar to that of alumine, but much less evident in its effects. When heated in an earthen retort, it loses only the small quantity of water it contains, and acquires a phosphoric property, according to the remark of Citizen Tingry, of Geneva. When rapidly rubbed on a hot plate of iron in the dark, it emits a phosphoric light: a property which is frequent in white bodies that undergo little alteration by fire. On a charcoal before the blow-pipe it remains unaltered, and merely gives to the flame, a slight yellowish colour. Magnesia is, therefore, one of the most apyrous earths.

7. There is no action, or perceptible attraction, between oxygen, azote, and magnesia. This earth produces no effect on those two gaseous substances. By exposure to the atmosphere, it attracts a small quantity of water and carbonic acid with extreme slowness.

In an experiment of Citizen Butini, half a gramme of magnesia, exposed for two years to the air in a porcelain saucer, covered with a small

small paper acquired an increase of one 144th part of its weight, and was in no respect changed.

8. No action is observed between magnesia and some of the combustible bodies, and between this earth and others, the action is very little. There is no action between it and hydrogen gas, nor carbon, the diamond, and the metals. Phosphorus combines so difficultly, and in so small a dose, that we are not acquainted with phosphorated magnesia. This earth acts rather stronger upon sulphur, with which it unites in a small proportion, either in the dry, or the humid way. When two parts of magnesia and one of sulphur are heated in a crucible, an orange yellow mass is obtained merely agglutinated, and without fusion, very sparingly soluble in water, that emits a little sulphurated hydrogen gas when moistened, and is very easily decomposed by fire. A slight heat must, therefore, be used to obtain this sulphuret of magnesia; because a stronger heat would separate the sulphur. It is not formed in the humid way but with difficulty. If two parts of magnesia, and one part of sulphur in powder with twenty parts of water, be heated on a sand bath, the fluid, becomes of a pale yellow, but never red, nor orange colour; slightly fetid, and very far from emitting the strong smell which characterizes the sulphurets, formed by the other alkaline earths, as we shall see in the following articles. Very little of the sulphuret of magnesia is formed

ed in this manner; the greatest part of the sulphur and magnesian earth remains without combination. As it unites with very small portions at a time, it also produces very little sulphurated hydrogen, so that the water which retains it, emits scarcely any. The solid sulphuret of magnesia is very speedily decomposed by the contact of the air; so that the attraction between this earth and sulphur may be concluded to be very weak. It absorbs sulphurated hydrogen gas very sparingly, and accordingly the hydro-sulphuret of magnesia is uncertain or unknown.

9. Magnesia is so little soluble in water that we might almost deny the existence of any attraction between these two bodies. It differs much from the other alkaline earths in this property. Citizen Butini found that water boiled with this substance, and left for more than three months in contact with it, does not take up more than a 10,000th part. Mr. Kirwan says, that about 7692 times its weight of water is required to dissolve it at a temperature of ten degrees. It is not, therefore, more soluble than flint and alumine. Notwithstanding this insolubility, magnesia forms a kind of paste with water, and absorbs it very perceptibly; we might even affirm, that like alumine it has a greater tendency to render water solid, than itself to become liquefied with that fluid. It is true that this property is much less evident than in alumine, and that the paste made with this earth

earth is brittle, harsh, and without ductility. According to Bergmann 100 parts of magnesia, thrown into water, then taken out and dried, increase in weight near one-sixth, or 18 parts in 100. Hence, we may conceive, why it happens that water, which contains only a few particles of magnesia, has no perceptible taste, does not change the most delicate blue colour, deposits nothing by exposure to the air, and leaves scarcely any trace of residue after its evaporation.

10. There is little attraction between magnesia and the metallic oxides. Some of them, however, among the most fusible, and the most vitrifiable when treated by heat along with this earth, absorb it in their fusion, and assume the form of coloured enamels.

11. Magnesia easily combines with all the acids, and forms peculiar salts, different from those afforded by all the other bases, whether by their crystallization, their taste, their solubility, or the attractions of their principles. The attraction of magnesia for the acids in general, is weaker than those of barytes, lime, and strontian. It is stronger than those of silice, alumine, zircone, and glucine. We shall see in the next section, that it follows with respect to the different acids, the same order of attraction as the fixed alkalis.

12. Perfectly refractory and infusible alone, it enters difficultly into fusion with silice, and alumine, singly taken, but, on the contrary, it
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flows easily when united with both these earths, and more especially when lime is added. It is to this mixture of foreign earths, that we must attribute the form of glass, which Citizen Guition observed it to take in his early experiments, when he used impure magnesia; and this also is the cause of the commencement of fusibility observed by Bergmann. There is no reason to doubt, but that barytes and strontian would produce, by their mixture with magnesia, flint, and alumine, the same effect as lime, and that they would favour, or decide the vitreous fusion of these united earths. For it is certain, that the more of earthy mixture there is in magnesian compounds, and the more numerous the different earths, the more evident is their vitrifiability, and that we cannot reckon magnesia alone among the earths capable of truly determining the fusion of the others. In this respect, it is very remote from barytes, strontian, and lime, which earths may be ranged among the true and most active fluxes among the alkaline matters; whereas magnesia in this property, as well as in all the others, has much less intensity. When it enters in a large proportion into vitrifiable mixtures, it diminishes their vitrifiability, and, in compounds already vitreous, it retards their fusion, and brings them to the state of enamels, or even porcelain, as will be shown in the following articles.

13. The intimate nature of magnesia is unknown like those of the preceding earths. No experiment

experiment proves that it is a modification of any of these earths. We only know, that it exists very abundantly in the water of the sea, where it is, no doubt, formed, but we have no notion either of the principles that compose it, nor the manner in which they are united.

14. A knowledge of the properties of magnesia, has greatly attributed to the progress of chemistry. It is often used for experiments in that science. In medicine, it is used pure as a corrector of acids, or absorbent earth, and is a slight purgative. It is also ranked among the antiseptics, because it defends flesh and the bile from putrefaction. It has particularly the greatest success in cases of poison by the concentrated acids. It is given diffused in water with sugar. In pharmacy, it may be used, according to Bergmann, to dissolve or suspend in water, camphor, opium, the resins, and gum resins, as well as to form very valuable tinctures with dry vegetable matters. It is also used in the rectification of ether. It is sometimes so abundant in stony compounds, that they are named magnesian stones, and it likewise constitutes, by its saline compounds, one of the mineralizers of waters.

ARTICLE VII.

Concerning Lime.

1. THOUGH the French word *chaux* (lime or calx) has long been used in chemistry, to denote several very different substances, and might seem proper to embrace in its generality, various matters which were thought to have been formed by heat (*chaleur*) of which the name is manifestly the origin of the word (*chaux*); it is, nevertheless, assigned in particular, to the acrid and alkaline earth, which has also been named calcareous earth, absorbent earth, anti-acid earth, quick lime. An error has long prevailed in the French language respecting the import of the word *chaux*. It was applied to this earth, and also to the oxides of the metals, in which pretended properties were formerly admitted analogous to those of the calcareous bases.

2. Lime was known and employed in the most remote ages, and is one of the materials which men have possessed from the highest antiquity; notwithstanding which, chemistry did not begin to acquire accurate notions respecting it till the middle of the 18th century. In the time of Stahl, and towards the first third part of that century, very little of its characters and properties

properties were known. This chemist beheld, in the union of lime and water, the formation of a salt by the combination of the earthy and aqueous elements, and formed no proper estimate either of its alkaline nature, or its solubility in water. Long dissertations were afterwards made on the pretended salt contained in lime, which was regarded as a kind of saline embryo. Dufay first evaporated lime-water in 1730, and imagined that he had, by that means, separated its salt. It was then thought that water, by dissolving this salt, was much stronger after its first application to lime, than other waters that were afterwards applied to the same lime, whence the denomination of the 1st, 2d, 3d, &c. lime-waters. Duhamel examined its combinations with several acids in 1747. In 1752, Macquer, in his chemical theory, still taught the ideas of Stahl, and it was not till 1755, that Black published the first accurate information respecting lime, by exhibiting it as an alkaline earth, identical in all its parts; existing, with all its properties, in natural compounds, and more especially masked, and rendered mild in chalk by the carbonic acid, which was then called fixed air, of which it can be deprived by calcination. Since this famous epocha, chemists, unanimously joining in support of the discovery of Black, have not failed to multiply their accurate experiments on the properties of this earth, its attractions, and combinations,

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and its history being now well explained is no longer obscure.

3. Lime is found very abundantly in nature, combined with various acids, forming the strata of mountains; sometimes dissolved in water, and also constituting one of the bases of stones. Sometimes it exists pure, but in a less quantity, in the neighbourhood of volcanos, enveloped indeed, in stones, which have defended it from the contact of the air. Wallerius affirms, that it is drawn up by the lead from the bottom of the sea on the coasts of Morocco. And it is also affirmed, that some mineral waters hold it pure in a state of solution. This earth appears to be the most abundant in the interior of the globe, and forms the greatest part in the composition of its several masses.

4. By art, it is extracted in the way of calcination in an open fire from lime-stones. These, in general, are composed of carbonic acid, water, and lime. The two first bodies are volatilized, and exhale in the air by the action of fire, and the lime remains pure; in this manner it is prepared for builders. Chemists choose the native carbonate of lime, pure and transparent; they pulverize, and put it into good retorts of earth, or of iron, or in a gun-barrel, and calcine it by a strong heat. In this manner they obtain a much purer lime than that of the lime-burners, because the compound, from which they separate it, contains nothing foreign to calcarous

calcareous earth. We shall resume this operation more at length, in the following section.

5. Lime thus extracted, has the form of a grey stone, or fragments more or less pulverulent and white, of a varied coherence, hot, acrid, urinous taste, though less strong than that of barytes and strontian, but much more so than magnesia, and of the specific gravity 2,300. It converts the syrup of violets to a green, and renders its colour rather yellowish. The acrid nature of lime, though it is not very caustic, is sufficient, nevertheless, to redden and inflame the skin, when it remains for some time applied upon it.

6. It undergoes no alteration from light, and when exposed to a strong heat it remains unalterable without melting. Nevertheless, it is softened in the focus of a burning glass. In a crucible of clay, it fuses on its edges at a very high temperature, but this happens by combining with the earth of the vessel. Before the blow-pipe it remains equally unaltered and infusible, however long and however strongly it is heated. Accordingly lime may be considered as a substance completely apyrous.

7. Lime has no attraction for oxygen, nor for azote; it absorbs neither of these bodies when in the gaseous form, neither does it take them from caloric nor the other bodies which contain them. The effects it undergoes in the air, are consequently owing not to those principles, but to the water and carbonic acid mixed in
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the atmosphere. By exposure to the air, lime in the solid form swells, cracks, and breaks, and becomes slightly heated, falls into powder, and acquires a great increase of volume, becomes more heavy, and is singularly divided, at the same time that its colour becomes of a very pure white. It is called the flaked lime, because after it has once passed to this state, it is no longer quick-lime, but has lost its property of heating with water. These phenomena are more speedy and evident as the air is more humid. The water which is absorbed by the lime, dilates it sufficiently to break wooden vessels in which it is contained. In this state it is much less acrid than before. To restore its first state, it must be strongly heated, and in this operation loses nothing but its water. These effects are also much less speedy and powerful in lime than in barytes and strontian, as we shall soon observe; and they prove, that the former has less tendency to unite with water, and give it solidity, than these two alkalis. Lime does not absorb the carbonic acid from the atmosphere but with much time, and passes to the state of carbonate with great difficulty.

8. Lime has no action upon hydrogen gas; it does not take hydrogen from the compounds which contain it; it has little action upon charcoal, the diamond, and the metals, but much upon phosphorus and sulphur. If phosphorus be put in small fragments at the bottom of a tube of glass closed at one end, and
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four or five times its weight of lime in powder be placed upon it, so that one-fourth of the tube shall remain empty;—if then that part of the tube containing the lime be heated by means of a furnace with open bars, through the bars of which the tube passes, and afterwards that part of the extremity where the phosphorus lies, this substance becoming fused and sublimed from the heated lime, speedily unites with it without disengaging itself, and escaping to burn at its surface. The whole mass becomes agglutinated, seems to melt and take the form of glass, forming an homogeneous compound, which when cold is solid, of a brown colour. It is the phosphoret of lime; it has no smell, is less fusible than the phosphorets of barytes and strontian; it changes and breaks spontaneously in the air, is insoluble in water, but is decomposed at the moment it touches the fluid; it cracks, produces an effervescence, and disengages bubbles of phosphorated hydrogen gas, which immediately take fire in the air. The fetid garlic smell emitted by the phosphoret of lime when moistened, is owing to this gas. A portion of the same gas, in proportion as it is formed by the decomposition of the water, unites with the phosphorated lime, and forms an hydrogenated phosphoret; so that the phosphoret taken out of the water and dried, bursts into flame when concentrated muriatic acid is poured upon it, which disengages phosphorated hydrogen

gen. It is sufficient that the phosphoret of lime should be somewhat moistened by the air to produce even this flame in abundance by the addition of the muriatic acid. It is also to this easy decomposition of water by phosphorated lime, that the abundant production of phosphorated hydrogen gas is obtained, according to the process of Citizen Raymond, by heating in an earthen retort, with the pneumato-chemical apparatus, phosphorus and lime, to which a sufficient quantity of water has been added to form a paste.

9. Sulphur unites very well with lime, and with different phenomena, according to the manner in which their combination is effected. When a mixture of these two bodies well pulverized is heated in a crucible, it melts, or rather agglutinates into an acrid, reddish, inodorous, fusible mass, decomposable by strong heat, from which the acids separate the sulphur. It is the pure sulphuret of lime, which was called calcareous liver of sulphur. As soon as this compound is moistened by the air, or by a small quantity of water, it changes its colour, becomes green and yellow, emits an extremely fetid smell, affords sulphurated hydrogen gas, and becomes hydrogenated sulphuret. When the sulphur and lime are united in the humid way, a simple sulphuret is never formed, but always an hydrogenated sulphuret, on account of the water which is decomposed. This is prepared, either by throwing water on
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very fresh quick lime, covered with fulphur in powder, in which case the heat of the extinction effects the combination; or by heating in a mattras fulphur and lime in powder, and at least ten times their weight of water; or otherwise, by heating lime water and fulphur. In the latter case, the quantity of fulphuret is very small, on account of the small quantity of lime which water can suspend. In the two first, an orange or yellowish-red fluid of a very fetid smell, penetrating, bitter, and acrid, is formed, in which the quantity of fulphur suspended is equal to that of the lime. This hidrogenated fulphuret of lime loses its colour in the air, becomes gradually decomposed, and speedily absorbs oxigen to such a degree that it may be used for eudiometrical purposes. The fulphur burns and becomes converted, first into sulphureous acid, and afterwards into sulphuric acid. The acids decompose it, precipitate the fulphur, and disengage hidrogenated sulphurated gas. It decomposes many metallic oxides, and by causing them to approach to the metallic state, forms water and metallic fulphurets.

10. Lime readily unites with sulphurated hidrogen. When this body is passed in the form of gas under a bottle filled with water, and lime diffused in it, the gas is absorbed, becomes mixed and combined with the lime, and renders it more soluble than it was before, at the same time that it forms calcareous hidro-

fulphuret. Citizen Berthollet remarks, that the sulphurated hydrogen saturates the lime in the manner of an acid, and gives it the property of crystallizing in prisms; which in 1779, when I saw and described them for the first time, I took for a calcareous liver of sulphur, as it was then called. This hydro-sulphuret of lime is very soluble in water, without colour, and has a strong and very fetid smell. The acids decompose it with effervescence, and disengage sulphurated hydrogen in the form of gas. The metallic oxides decompose sulphureous hydrogen. This body is probably contained in ores and in waters as a mineralizer. Lime, therefore, like all the alkaline substances, has three kinds of combination with sulphur, namely, sulphuret, hydro-sulphuret, and hydrogenated sulphuret.

11. Though we are not yet acquainted with any immediate union between lime, carbon, diamond, and the metals, it cannot, however, be denied but that an attraction exists between these several bodies, particularly carbon. It is found, that when carbon in a state of minute division is heated with lime, they contract a strong adherence together, so that it afterwards becomes difficult to separate them exactly and completely. Lime is often found intimately combined with carbon in the coal of organic matters, and in some kinds of pit-coal. The sulphuret, and even the hydro-sulphuret of lime, dissolves carbon by the assistance of heat, and retains it even in the liquid state. With regard
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the metals, though lime never contracts any union with them, its attraction for some of their oxides is so great as to favour the decomposition of water by these combustibles and their consequent oxidation.

12. Water exercises a very strong attraction upon lime. When this liquid is thrown in small quantity on a solid piece of lime, or upon this earth in powder, but in a very caustic and unflaked state, the fluid is speedily absorbed; and the lime appears as dry as before. Soon afterwards, if it be in a solid state, it bursts, cracks, and flies to pieces. The caloric which is developed, is disengaged with a portion of the water converted into vapour. This vapour has a faint smell of ley, and converts the colour of paper, tinged with mallow flowers, to a green, which shows that the volatilized water carries with it a small portion of lime. In the dark, lime during this process of heating and dividing by means of water, is luminous and phosphoric; particularly in hot weather. In this dry extinction, the calcareous earth, extremely divided and increased in bulk, falls into very fine dry white powder; its weight is found to be increased, and it is no longer acrid and caustic as before, neither does it give out heat upon the addition of more water. These phenomena are of the same nature, but merely less intense than those which take place with barytes and strontian, as will be seen in the following articles; and they depend like them

on the strong attraction of lime for water, and its property of disengaging much caloric. They prove that in this combination, the water assumes a solid and icy form. La Place and Lavoisier in their calorimetric researches found, therefore, that one part of a mixture of lime and water in the proportion of 16 to 9 of these two bodies, fused one part and a half of ice at the freezing point of water. It is a proof that the water in flaked lime, in a dry state, is solid and even more solid than common ice, as it is known in our temperate climates, that lime cooled several degrees below 0, and mixed with half its weight of ice at 0, disengages a sufficient quantity of caloric to raise the temperature of the mass more than forty degrees of the thermometer of Reaumur. Lime, thus mixed with water in a solid state, is called dry-flaked lime. If more water be added, it becomes diluted without heating, and is improperly called milk of lime on account of its whiteness and consistence. If a sufficient quantity of the water be added, the whole is dissolved; and it acquires the transparency and fluidity of water. For this purpose, more than four hundred and fifty parts of water are required for one of pure lime. The solution is called lime-water.

13. It was formerly unknown that the whole of lime is soluble in water. The first water was thrown away, because it was thought to be too acrid, and the second, or third solution only were taken for use. Accurate experiments having

ing since proved that very pure lime is totally soluble, even to the last atom in water, lime water is often prepared, by throwing into a sufficient quantity of distilled water, the powder of lime, which is then kept in well-closed bottles. When the water ceases to dissolve this earth, it is filtered, or drawn off by a syphon, and, in this state, it is found to contain one 450th part of its weight.

14. The solution of lime, denominated lime-water, is clear and limpid, and its specific gravity is scarcely superior to that of common water. Its taste is acrid, hot, disagreeable, and urinous, and it speedily changes syrup of violets to a green. When evaporated in closed vessels, a small quantity of the lime is carried up with water, and that which remains is usually flaked lime. In order to convert it to the state of quick or caustic lime, it would be necessary to give it an increase of temperature more considerable than can be applied in the usual distilling vessels.

Lime-water, exposed to the air, absorbs carbonic acid, and becomes covered with a dry pellicle, which is renewed at the surface, when broken, until the whole of the lime is thus separated from the water. The pellicle consists of carbonate of lime which is insoluble, and was formerly called cream of lime, though very improperly. The same substance was also considered, in the earlier states of chemistry, as a salt of lime, and it was this fact which led Stahl to conclude,

conclude, that the union of earth and water formed a salt.

Lime-water is, in no respect, altered by oxygen, azote, and the greatest number of combustible bodies. It absorbs a small quantity of sulphurated hydrogen gas, which it changes into hidro-sulphuret; it dissolves also a small quantity of sulphur by the assistance of heat, but it takes up no portion of carbon, the diamond, nor metallic matters: water only dilutes and weakens it.

15. Lime unites with the metallic oxides, both in the dry and in the humid way. Most of the oxides flow with lime by heat into enamels, or coloured glasses; some of them combine with it by means of water, and form salts in which they seem to act as acids. Of this we shall speak more fully in the particular history of metals.

16. Its attraction for the acids is considerably strong, and it combines more or less easily with all these bodies. The salts it thus forms, are found among natural fossil products. In order to present, in this place, only the general notions of the facts which ought to be found in the history of lime, all the particularities relative to its combinations with acids, being to be exposed in the following section; we shall include only what relates to its attraction for the acids, and the order of these attractions compared with that of the other bases for the same burned bodies. To begin with the strongest

est acid, this power acts in the following order; sulphuric, nitric, muriatic, phosphoric, fluoric, phosphoreous, sulphureous, nitrous, boracic, and carbonic. By comparing these attractions with those of the other salifiable bases, we find that it is constantly placed after barytes, and strontian, frequently after the fixed alkalis, sometimes before them, and constantly before ammonia, magnesia, glucine, alumine, and zirconia.

17. The adherence and intimate union between lime and siliceous stones, being the foundation of many very useful chemical arts, it is necessary that they should be carefully described in the theory of the science. This earth contracts a strong adhesion with fragments of siliceous stones, when their juxtaposition is assisted by water. When coarse sand is mixed with lime newly flaked, or with quick lime sprinkled with a little water, these two bodies a few moments afterwards become consistent, and form what is called mortar. The state and proportion of the lime, its previous extinction with various quantities of water, or its extinction made at the very moment of the mixture, the nature of the sand more or less coarse, rounded or unequal, dry or humid, present great differences in the different mortars thus prepared.

The result of the inquiries of La Faye on the mortar of the ancients, published in 1777 and 1778, show that the Romans succeeded in giving great solidity to their constructions, merely by the accurate proportions of the mixture of lime,

lime, flaked in a particular manner and rough sand. Very good mortar is also made with lime and baked clay, or pouzzalana, a kind of ferruginous clay, baked by the fire of volcanos, and altered by the contact of water and air.

18. Lime, though like filex it is perfectly infusible alone, yet melts with this earth when heated in such a proportion, that the lime shall, at least, equal the filex in quantity. It appears even that lime is the natural flux of filex in the fusible stones, of which these earths constitute part. With this view, the quantity of lime used in some glass works is so considerable, as to afford ground to affirm, that it supplies the place of fixed alkalis.

Lime is likewise capable of fusing alumine, in the dose of one-third of its weight. It appears even that like barytes, and the alkalis, it has a stronger attraction for alumine than for filex. The mixture of these three earths, melts more completely than that of lime with either of them separately. In this manner it is, that one part of lime, and one of alumine, are capable of melting two, and even two and a half parts of filex. From this fact it is, that the fusibility of several scintillating stones composed of these three earths is explained. Hence also we see, why lime, very strongly heated in crucibles, becomes vitrified at its edges, where it is in contact with the sides of the vessel, on account of the filex and the alumine, which enter into their composition. We are not yet acquainted with
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the action of lime on zircon and glucine. It appears that it melts with these earths which mutually serve as fluxes for each other.

20. The intimate nature of lime is not known. It was formerly considered as being charged with fixed fire during its calcination, and susceptible of giving it out during its extinction. But this notion was not calculated to show its composition. By an hypothesis arising from the former, Meyer has admitted in lime, the existence of combined fire with an acid, under the name of *causticum* and *acidum pingue*. But he has not proved the existence of this pretended principle of causticity, which has hitherto been considered as an ingenious fiction by all chemists. It was afterwards thought, that lime is the product of siliceous or aluminous earths, divided and attenuated in the organs of animals. But no positive experiment supports this theory which is purely hypothetical. As calcareous earth is found abundantly diffused in the water of the sea, and particularly in the numerous class of shell fish, zoophytes and lithophytes, naturalists have supposed, that it is formed by these animals, by the action of their organs. But, on the one hand, the existence of a great quantity of calcareous earths in numerous mountains, without any trace of animal organization, and, on the other hand, our total ignorance of the nature of the principles of lime, and the manner in which the life of animals can unite them, still place this opinion
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in the rank of hypotheses. Lime, moreover, exists abundantly in vegetables, in which we ought first to explain its formation, because it is more natural to think, that it passes from these into animals, for the nourishment of which nature has manifestly destined and appropriated them, either by their order of composition, their pre-existence, or their mass compared with that of animals. Some facts seem to authorise us in admitting the presence of azote in lime, as well as in general in all the alkaline earths. Those facts will, hereafter, be shown; but we must here state, that they have not been observed with sufficient exactness, nor is their number so considerable as to admit of their being placed among the admissible truths, constituting the elements of a positive science. Besides which, even if we could prove the presence of azote in earths, and its alkaligene property of which I shall speak, is a mere notion, though this notion is my own, we shall still have made but a small progress in the analysis of lime; for it would be necessary to ascertain, not only the matter combined with azote in this earth, and the proportion of its principles, but also their difference in the other alkaline earths. We have, therefore, no positive knowledge of the intimate composition of lime.

21. Lime is one of the earthy bodies most frequently employed by nature, and most abundant in its numerous combinations. Besides those immense beds of calcareous salts deposited
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in the mountains, besides the very multiplied and diversified stony compounds of which it is one of the principles, we find lime often in a pure state in vegetable substances. In animal matters it is united to various acids. It is one of the earths which passes through them, and is formed in them in the greatest quantity, and is the most necessary to their existence. We do not yet know whether it is carried thither by their food, or is composed in their organs. By studying the properties of lime, as has been done for forty years past, natural philosophy has been greatly advanced, and this earth has been used as a very valuable instrument of analysis.

22. There is no material more useful in the Arts, or more variously employed, than lime. It forms the basis of many constructions; it connects the materials, constitutes the solidity of mortars and cements, and serves for the preparation of stucco. It forms covering or facing to receive coarse painting upon walls. The ancients disposed a thick stratum upon a first layer of black, and by tracing through this they formed coarse outlines. Lime is used in glass-works, in soap lees, and the fabrication of soap. The inner surface of casks is impregnated with this material when designed to preserve water at sea; and animal matters are in many cases covered with lime, to dry and defend them against putrefaction. It enters
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into a number of preparations of vegetable and animal matters--dyeing, tanning, &c. &c.

23. In medicine, lime-water, more or less diluted with water or with different liquids, is prescribed in cases of internal or external ulcers, and as a lithontriptic. In the last case it is very far from possessing all the virtues which have been attributed to it. It has been thought that its indiscreet or too long continued use produces a manifest tendency to septicity in the fluids. Lime-water is more useful as an anti-acid or absorbent, by rapidly condensing the carbonic acid gas, which distends the intestines. As a carminative, it speedily cures intestinal tympanites; but it cannot be compared with the alkalis of which it does not possess the energy upon animal matters.

24. Lime is of the most extensive and important use in agriculture. It is applied as a most valuable manure for the purpose of dividing earths, assisting vegetation, warming cold soils, which are too dense and argillaceous, and destroying insects and weeds which frequently vitiate whole fields. It immediately destroys the blight in corn, and prevents its reproduction by destroying its contagious property; its use in this case is called chaulage. It consists in steeping and agitating for a short time the grain in lime diluted with warm water before it is used as feed. Experience has confirmed the success of this method.

25. In

25. In chemistry lime is one of the principal agents of our laboratories. It is dissolved in water for the preparation of lime water, one of the most frequent and necessary re-agents. It renders the alkalis caustic, decomposes many salts, metallic solutions, and soaps, is of use to ascertain the presence of carbonic acid, to determine its quantity, &c. &c. Lime is mixed with white of egg, and applied to the junctures of glass vessels to which it strongly adheres, and forms an accurate closure. The same mixture is used to repair broken vessels of glass and pottery, or to preserve them for a time, by preventing the total separation of their broken parts.

ARTICLE VIII.

Of Alkalis in general.

1. THE word alkali is transmitted to us by the Arabs; it was at first spelled with a *k*, and is derived from the word *kaly*, a plant from which was extracted that species of its bases the most anciently known, and the first employed. The Arabs, by adding the particle *al*, intended to express the force, or the superiority of the salt obtained from the plant, over the plant itself. I have taken the *k* from this word, and have substituted a *c*, because the former letter being little used, and not very expressive in our
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(the French) language, is an unnecessary and redundant letter, and, in this instance, serves only to embarrass the student *.

2. Among those earthy substances, of which the history has been just given, two species were lately classed, which have very evident alkaline properties, and which I shall connect with what are properly called alkalis, as well on account of the energy of those properties, as in consequence of the force of attraction they exert upon the acids. Barytes and strontian, in fact, bear such an analogy to the alkalis, that they cannot be far removed from those bodies, and it is even impossible, in many instances, to avoid comprising them in the same genus.

3. There are a certain number of properties enjoyed almost exclusively by the alkalis, which, on this account, are expressed by the name of alkaline properties. The acrid taste, analogous to that of putrescent animal substances is an alkaline character: it is designated by the name of urinous taste, because it resembles that of putrid urine, which itself has this taste only from the species of alkali thus formed in it. Every alkali changes, more or less to a green colour, the syrup of violets, the red of poppies, of roses, the skin of radishes, the bluish tincture of mallows, and causes the yellow tincture of curcuma,

* These reasons here given did not appear sufficiently applicable to our language and usage, to induce the translator to depart from the present adopted spelling. N.

or *terra merita*, to change to a reddish brown, or deep violet. The alkalis have, besides, the property of readily combining with the acids, and of forming, with them, salts, properly so called; for this reason, they are comprised among the salifiable bases, and they are placed even in the first class of these bases, on account of the saline properties they communicate to the acids, and the force with which they adhere to them.

4. The energy of alkaline substances upon animal matters is infinitely greater than that of the alkaline earths. All the alkalis, however, have not the same poisonous action upon animals as barytes; but they dissolve animal substances, soften them, reduce them to paste, and totally decompose them, as will be explained hereafter.

5. I acknowledge five species of alkalis, which are very distinct from each other. Four may be considered as fixed alkalis, not because they all possess absolute fixity, for two of them may be sublimed by a great heat, but because, on comparing them with the fifth, which is easily reduced to vapour, or gas, they are really very difficult to be evaporated. This fifth species has also been denominated volatile alkali, in opposition to two of the former, which only were known formerly. The names of the five alkalis at present adopted, are *barytes*, *pot-ash*, *soda*, *strontian*, and *ammonia*.

6. All

6. All the alkalis are unchangeable by heat ; whether sublimed, melted, or reduced to vapour, they lose no portion of their nature or properties. They are all without action on oxygen and azote gases ; all absorb from the atmosphere the water and carbonic acid which are dissolved in it. None of them act either upon hydrogen gas, carbon, or the diamond ; but they unite with phosphorus, sulphur, and with the phosphorated, sulphurated, and hydrogen gases. Although they do not combine with the metals, they are frequently susceptible of favouring their oxidation by water, which they render more decomposable by these combustible bodies.

7. The alkalis all combine with water, with more or less force : they disengage caloric from it, and render it more dense than it is in its natural state. They also combine with several metallic oxides, which often exert an action upon them similar to that of the acids.

8. The attractions and combinations of the alkalis with acids, produce salts, the properties of which vary according to the species of acids, and alkaline bases united together. Their relative attractions for the generality of the acids is constantly in the following order ;—barytes, pot-ash, soda, strontian, and ammonia ; with respect to the other salifiable bases, barytes is constantly stronger than lime ; pot-ash and soda sometimes only give way to lime, which they also frequently displace ; they are constantly stronger than magnesia, alumine, glucine, and

and zircone. Ammonia only partially disengages magnesia from its saline compounds, and almost always totally separates the three latter from these earths. It will be seen in the history of the salts, that their most remarkable properties are owing to these attractions.

9. The earths in general undergo little alteration on the part of the alkalis. Silica and alumina are the only two which are soluble in them, and adhere more or less strongly. They may be united either in the dry or the humid way.

10. The five species of alkalis contract no real union, and do not react upon each other. They are only displaced from their respective combinations according to the diversity of their attractions for the different bodies.

11. They are all five found in considerable abundance in Nature, never pure or isolated, but in combination, either with the acids in the state of salts, or with the earths, and in the state of stones. Their saline compounds are often found in the juices of vegetables, and in animal fluids. Formerly, even when three species of alkalis only were admitted, pot-ash, soda, and ammonia, one of these alkalis, namely, soda was supposed to belong particularly to minerals, pot-ash to plants, and ammonia to animals; but this division has been found to be much less exclusive than it was long believed to be, each of these salifiable bases being found indifferently in one or other of these three

classes of bodies. Nevertheless barites and strontian have not yet been met with, except among fossils.

12. Of the five species of alkalis, there is only one, the nature and composition of which is exactly known. An accurate analysis has been made of ammonia, which has been confirmed by synthesis. This information being once acquired, led to the proposal of some opinions or views relative to the principles of pot-ash and soda, which have not yet been decomposed; but these observations ought still to be considered only as hypotheses. I was the first who suspected and announced, in the year 1787, that azote, an element well distinguished in ammonia, might be the general principle of the alkalis, the *alkalifiant* or *alkaligenant* principle. It is in consequence of this notice, that several chemists have regarded, though doubtless too precipitately, this result as a demonstrated fact: I ought therefore to observe here, that though this suspicion has not yet been overthrown, it has not been proved by any positive experiment; that the inquiries that have been made for its support, have not yet had the success which I had anticipated; and that in order to admit it as a point of doctrine, a series of experimental data are yet required.

13. It cannot be denied, that it is very probable that the alkaline properties which are similar, not only in the two fixed alkalis, but also in barites, strontian, and lime, may be
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owing to an identical principle. We cannot avoid admitting, that of the two materials which have been found on the analysis of ammonia, azote appears to be that which may be regarded as the alkalifying principle; that this idea agrees with the tendency possessed by all the substances which contain azote, to include at the same time a portion of alkali; that it would also be very conformable to the simplicity and uniformity of the views of nature to consider atmospheric air as a mixture of oxygen and alkali, as its influence appears to be equally marked and necessary in the formation of acids and alkalis, in acidification and alkalification. But all this is still only a frail assemblage of hypotheses, and will continue to be so, as long as exact experiments, similar to those which have been made upon the acids, shall be wanting to decide upon the four other species of alkalis; and as I shall show in the following articles, that there are no similar results in chemistry, I ought, still more than another, as the first author of this notion, to present it only as a sketch or outline, far distant from that rigorous demonstration which is now necessary to produce conviction as to the nature of bodies.

14. It is the more necessary to adopt this cautious opinion, as I had proposed my hypothesis only for pot-ash and soda, which I compared, by some notions which will be stated hereafter, to lime and magnesia; and that since

this proposition, which was made about fifteen years since, my first notion has not only been unconfirmed by any strict fact, but the discovery of barites and strontian, the most intimate knowledge of their remarkable properties, the necessity which the state of the science imposes upon me to reckon them among the alkalis, still weaken the foundations of my old hypothesis; and I have, in short, no longer any *comparative* opposition of two fixed alkalis to two earths slightly alkalified, which in a great degree suggested the hypothetical suspicions of which I speak.

ARTICLE IX.

Of Barites

1. BARITES takes its name from a Greek word, which signifies heavy, because it is the heaviest of all the salifiable, earthy, and alkaline bases. At first, on account of this property, it was denominated *heavy earth* and *barotes*. Mr. Kirwan and Bergmann defined it by the Latin name of Barites, and it is this word which the authors of the French Nomenclature have translated into their language; it is at present generally adopted. It has been generally regarded till now as an earth; I not only place it among the alkalis, but I place it as the first of their species, because its alkaline properties

properties are the most energetic, and its attraction for acids the strongest.

2. Barites has long been confounded with absorbent or calcareous earth, even by Marggraff and Citizen Monnet, who, on examining *heavy spar*, from which it is extracted, had nevertheless remarked some difference between it and calcareous substances. Gahn and Scheele, the Swedish chemists, were the first who distinguished it in 1774, and who, by denominating it *heavy earth*, described some of its most essential characters. Since their discovery, all the chemists have confirmed the distinction of this species of salifiable bases, but they have all confounded it with earths. Those who have greatly contributed to the primitive labours of the Swedes, and to whom we are indebted for the whole extent of the exact information which we now possess of barites, are Messrs. Hope, in Scotland, and Pelletier, Vauquelin, and myself, in France.

3. Barites never exists in a pure state among the natural productions in which it is contained, but combined with various acids, or with several earths. Before the investigations of the last mentioned chemists, pure barites was unknown; it could not be extracted or obtained in a pure state, and one of its combinations with the carbonic acid was substituted. To separate it from its compounds, and to obtain it in a great degree of purity, different processes were had recourse to, according

according to the nature of the baritic combinations that were treated. Without here entering into details which belong entirely to the history of the salts, it is nevertheless necessary to be known, that barites is extracted from the carbonate or the fulphate of this alkali, which are abundant in nature, but particularly the latter. The first of these salts is calcined in a crucible surrounded with charcoal, with which it is mixed, and which favours the disengagement of the carbonic acid. The fulphate of barites, in a fine powder, should be mixed with one-eighth of its weight of charcoal powder, and heated for several hours at a red heat in a crucible: the fulphuret of barites which results, is then diffused in water; some nitric acid is poured on it, which precipitates the sulphur; the nitrate of barites is made to evaporate and crystallize; it is afterwards strongly heated in a retort, and by the total decomposition of its nitric acid, it leaves the barites pure. A portion of muriatic acid is often added to the solution of the fulphuret of barites; the muriate of barites is precipitated by an alkali saturated with carbonic acid, and the carbonate of barites, precipitated by charcoal, which facilitates, as has already been said, the volatilization of the carbonic acid. This last process, like that of the calcination of the carbonate of native barites, in the midst of charcoal, a process which is attributed to Mr. Hope, of Edinburgh, does not afford the
barites

barites very pure; it is only the decomposition of the nitrate of that base by heat, which affords it in that state. This method was discovered by Citizen Vauquelin.

4. Barites obtained by the processes pointed out, is commonly in the form of small masses, which are grey, porous, tolerably solid, fusible, breaking by a hardish pressure; it has an acrid, burning, urinous, and caustic taste, which is quickly venomous when it acts upon the stomach and intestines. Its weight is to that of water, as 4 to 1. It destroys and disorganises animal substances like the other fixed alkalis. It decomposes them, and converts them into ammonia and oil. It changes blue vegetable colours to a deep green, and attacks, even in their composition, several of these colouring particles. All these properties render it exactly similar to pot-ash and soda, with which there will, in the sequel, be discovered several other analogies equally marked.

5. Light does not in any degree alter barites. When heated before the blow-pipe upon charcoal, it melts in a grey opaque globule, which soon scatters and is dispersed at the surface of this combustible body. On being treated by heat, in a crucible or retort of porcelain, which is made red-hot, it becomes soft, melts, and sticks to the sides of those vessels, where it forms a kind of greenish coating, that adheres very strongly. If it be heated less quickly,

quickly, it hardens and acquires internally a blueish shade of green.

6. It does not absorb either oxygen or azote gas, and has no action upon their basis, which it does not take from any substance. When exposed to the air, particularly when it is humid, it becomes inflated in a few minutes, grows hot, and divides into a white dust, which occupies several times its primitive bulk. It loses a part of its hardness, and increases in weight to 0,22.

It is to the absorption of the atmospheric water, that these phenomena are owing. They take place in a more speedy and sensible manner, on account of the transpiration of the skin, when some fragments of this alkali, very pure and caustic, are exposed upon the hand. The surface which touches the hand immediately becomes white; it bubbles up, falls into powder, and produces so much heat, that it is difficult to support this effect for some time. The absorption and fixation of atmospheric water, as well as the disengagement of caloric by well-prepared and very pure barites, are so energetic, and so forcibly dilate this alkaline substance, that when we expose to this extinction (for this is the name which this phenomenon ought to bear, analogous to that which has already been described in the history of lime) a portion of barites melted on a fragment of porcelain, the latter is broken with noise by the effort exerted by the dilated particles of this alkaline base.

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When this first effect, produced by the absorption of atmospheric water, is over, when the barites is entirely extinguished, it at length absorbs carbonic acid from the atmosphere; it always loses more and more of its acrid taste, and becomes effervescent.

7. Among the six kinds of undecomposed combustible bodies, the history of which has been given in the second section of this work, after azote, there are only two upon which barites appears to exert any attraction; for it does not unite to hydrogen, or to hydrogen gas, and it experiences no alteration on the part of carbon, charcoal, the diamond, or metals, which are, likewise, not affected by the barites. The two combustible bodies upon which barites acts are phosphorus and sulphur. A faint idea only was entertained of this action, and it was only discovered by complicated processes, before the means were known of obtaining barites in that state of purity in which it is now known and employed. When barites is heated with phosphorus in a glass tube rather thick, which is held in the midst of lighted charcoal, these two bodies combine rapidly together. The compound which results from them is blackish, or of a brilliant brown, nearly resembling a very fusible metallic substance; emitting, when moistened, a strong and fetid odour, luminous, in the dark, decomposable in the air, affording with water, which it decomposes, phosphorated hydrogen gas, and is gradually converted

converted by the air into phosphate of barites. This compound ought to be denominated phosphuret of barites.

8. A combination analogous to the preceding takes place between barites and sulphur. In the cold, these two bodies exert no action upon each other. By the addition of hot water, the barites dissolves more than one-fourth of its weight of sulphur. Heated in a crucible, these matters when well mixed, melt as soon as they are perfectly ignited: the result is a yellow reddish coloured mass, which is very soluble, but more so in boiling than in cold water, suddenly decomposing that liquid, saturating it with sulphurated hydrogen, depositing on cooling crystals of hidro-sulphuret of barites very different in their form, sometimes resembling that of small needles, at others that of hexahedral prisms in considerable abundance, sometimes that of octahedrons, and often also that of small hexagonal, brilliant, and micaceous laminae. At the moment at which the solution of the sulphuret of barites takes place, it emits a fetid smell of sulphurated hydrogen gas: before being united to water, this solid sulphur is absolutely inodorous. The liquor which has deposited crystals of hidro-sulphuret of barites, retains an hydrogenated sulphuret of the same base. Exposed to the air, the solution of sulphuret of barites, becomes of a yellow citron-colour. We often observe, crystals of hidro-sulphuret of barites

rites will have yellow spots, or plates, in the midst of their white masses.

This sulphuret of barites is very remarkable for the extreme quickness with which it decomposes water, for the quantity of sulphurated hydrogen to which it combines, which it retains, and with which it forms the condensed baritic hidro-sulphuret, for the difficulty and slowness with which the air decomposes the latter, as well as for the great proportion of sulphurated hydrogen gas that is disengaged without any precipitation of sulphur, when it is treated by the acids. Citizen Berthollet, who carefully examined this body, dissolved in water, and who first gave it the name of hidro-sulphuret of barites, considered the union of sulphurated hydrogen with barites, as performing the function of an acid. The redness which sulphurated hydrogen gas gives to the tincture of turnsol, its absorption, and speedy combination with the solution of barites, the saline crystallization formed by this combination, its permanence in the air, its decomposition by the acids, which disengage from it sulphurated hydrogen gas, with a brisk effervescence; in short, the greatest attraction which sulphurated hydrogen exerts upon barites, from which it separates and precipitates sulphur, since it decomposes the sulphuret of barites, all authorize and strengthen this opinion.

We ought to distinguish three kinds of combination of sulphur with barites. In one of these

these the fulphur is alone, and immediately combined, as when it is heated in a dry state, with the barites, this is the simple fulphuret of barites. In the other, the fulphur combined with hydrogen, exists in the state of hidro-fulphuret of barites: this last combination is obtained by passing fulphurated hydrogen gas into water in which barites has been diffused: the barites becomes more soluble than when it is alone, in proportion as it becomes united with the fulphurated hydrogen, which condenses, and is absorbed by the liquor. Lastly, between this latter state of hidro-fulphuret and fulphuret of barites, the distinctive character of the first being that of only affording by the acids fulphurated hydrogen gas, and no precipitated sulphur; and the character of the latter treated in heat in the dry way, being that of affording only sublimated sulphur, without fulphurated hydrogen gas,—between the two extreme terms of combination is found a third kind of union, in some degree intermediate, in which the fulphuret of barites holds in solution more or less fulphurated hydrogen, so that it at once gives by the acids which decompose it, both fulphurated hydrogen gas which is disengaged, and sulphur which is precipitated. Citizen Berthollet defines this mean combination by the name of *hydrogenated sulphuret of barites*. It appears that the barites must dissolve, at least, one-tenth of its weight of sulphur, before it can be in the state of a sulphuret; in other respects, the *maximum* of this solubility

solubility of sulphur it not yet known. It must be observed, that what has just been said of the union of sulphur with barites, and of the three principal states of this combination, viz. *sulphuret*, *hidrogenated sulphuret*, and *hidro-sulphuret*, may be applied in general to all alkaline matters.

10. Barites has much attraction for water. All the phenomena which they present with this body, in the liquid state, are very necessary to be well known. If a small quantity of water be poured upon some pieces of very strong and caustic barites, it boils up with a noise, becomes very hot, increases in bulk, and changes into a white and apparently inflated substance. If a quantity of water be added sufficient to dilute it, after having been heated and inflated, it hardens and crystallizes on cooling; it takes a firm consistence, and preserves, in a needled form, the appearance of a stone, which, after some time, divides and falls spontaneously into dust in the air. If more water be employed than in the preceding experiments, the barytes is entirely dissolved in this liquid. Cold water takes up about a twentieth part of the weight of it. This solution changes the syrup of violets to a deep green, and soon destroys its colour. Exposed to the air, it is speedily covered with a thick pellicle, which is reproduced in proportion as it is taken off. This effect is owing to the absorption of the carbonic acid of
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the atmosphere; evaporated in closed vessels the solution of barites leaves the alkali pure.

Boiling water dissolves half its weight of pure barites. This solution crystallizes on cooling; it affords long prisms with four sides, white and transparent, which effloresce in the air, lose a little of their water of crystallization, and absorb the atmospheric carbonic acid.

11. We are still almost entirely ignorant of the combinations which barites is susceptible of forming with the metallic oxides. It appears that it is capable of uniting with several of them, as well as with the acids, though less easily and less generally. It will be seen in the history of lead that it very readily dissolves the oxide of this metal.

12. Barites quickly unites with all the acids. It adheres so strongly to those bodies, that it forms with them the most permanent saline compounds, and the most difficult of all to be decomposed: it is particularly by this property, that it deserves the first rank which I assign it among the alkalis. Most of the salts of which it forms the base, are either little soluble and pulverulent, or soluble and very crystallizable; it is the base which has the greatest attraction for all the acids, and which carries off most of them from all the others. It is sufficient here to notice these general results, because the salts which it constitutes, will be examined in particular and in detail in the following section.

13. Barites

13. Barites has a marked action in the dry way upon flint and alumine, of which it effects a vitreous fusion at a high temperature: it takes and gives to these earths in their vitrification, a green or bluish colour, which has caused a suspicion that it is formed of a metallic oxide. With zircon, it is also susceptible of melting into glass; it does not dissolve it more than the two first earths in the humid way; it precipitates it from its solutions in the acids, as it also acts with respect to alumine; it does not unite to any of the other earths in the humid way, but combines with them more or less by the action of heat, by forming with them compounds more or less vitreous. In this union, effected between barites, flint, and alumine, an union which connects it still more with pot-ash and soda, the barites loses part of its taste and solubility, and gives to the first of these two earths, insoluble by itself in the acids, an extreme state of division which favours its solubility in liquids. It may, therefore, serve for the analysis of hard stones, like pot-ash, and soda; it is easy to foresee, that similar combinations between barites, flint, or alumine, may form some natural stony compounds, which mineralogical chemistry will hereafter discover among fossils which have been hitherto imperfectly examined.

14. Some modern-chemists have thought that barites was only the oxide of a metal still unknown, and very difficult to be reduced. They
were

were led to this opinion by its weight being greater than that of any other earthy or alkaline base, by that of the saline compounds of which it forms a part, by the colour which it contracts merely by heat, and gives to the earths with which it is combined by the act of fusion, and by the precipitates analogous to those of the metallic solutions it affords in certain circumstances. Such was long the opinion of the celebrated Bergmann : such was that of the illustrious Lavoisier, which he extended in general to all earthy matters. It has even been asserted that Gahn, the Swedish physician, had succeeded in obtaining the metal of barites ; but this fact has not been confirmed, and as long as no process has been discovered for decomposing this pretended oxide, to separate the metal and oxygen from it, as has been done with all bodies which are classed among the order of metals, the opinion relative to the pretended metallic nature of barites, as well as of the other falsifiable, and particularly earthy bases, will be nothing but a mere hypothesis. Its resemblance to fixed alkalis, at present so natural, still deprives this notion of part of its former probability.

15. Barites in its state of purity, is only employed in chemical laboratories, for the formation of salts, and for estimating the attractions of the bases with the acids. Its solutions in water and in the acids, are employed as very useful re-agents.

If we could succeed in obtaining it abundantly and easily, it would become very useful in the manufactures, for decomposing many salts, and obtaining their bases pure, as I shall show in several articles of the following section. Already have the late discoveries to which it has given rise, its strong attractions, its property of absorbing and solidifying water, and of acquiring a great degree of hardness in its extinction, contributed to the progress of the science, and must have an influence on the processes of the arts.

Some physicians have imagined that barites may be employed as a very energetic medicine; and, in fact, they have hitherto given it only combined with the muriatic acid. There is every reason to believe, that this alkaline base, when pure, is a violent poison, since when combined with the carbonic acid, and having lost all its acrid taste by this union, it speedily poisons animals. Mamiferous animals which have been made to take it, have experienced acute pains, convulsions, vomiting, and death. Their stomach and intestines were inflamed, spotted, sphacelous, and even, as it were, in some parts corroded: its administration in medicine must, therefore, require great caution.

ARTICLE X.

Of Pot-ash.

1. THERE has long been known in the arts and commerce, under the name of pot-ash, an alkaline matter, acrid, burning, caustic, deliquescent in air, which is prepared in the north of Europe, and in North America, by burning the wood of their inexhaustible forests, and calcining its ashes till they were made to experience a more or less complete fusion. This word is formed from two other German words, implying *the ashes of pots*, because this alkali was for a long time calcined in pots. This species of alkali has also been defined by the names of fixed alkali, because it was for a long time the only kind known, and considered as the primary alkali; of *alkali of nitre* and *alkali of tartar*, because it was often extracted from those two substances; of *vegetable alkali*, and the *fixed salt of plants*, because it was obtained in abundance from burned vegetables; of *deliquescent alkali*, because it was supposed to be the only alkali which had the property of attracting moisture from the air. A celebrated chemist at Berlin, very lately proposed to distinguish it by the simple word alkali, the reason for which will soon be explained; but this expression

pression would not only thus be taken away, in some degree, from the genus of those bases which it characterises; it would also be perpetuating an ancient error, since the plant called *kali*, from which it derived its origin, is not that which furnishes this species; besides, the word pot-ash was adopted twelve years ago, and we ought not for an inaccurate, and even erroneous denomination, to abandon one that is generally received.

2. Pot-ash has only within a few years been known in its state of purity. It was not till immediately after the discovery of Black, relative to the two states of alkaline substances, their causticity, and mildness, as this celebrated chemist asserted, that exact notions were entertained of its properties; and eighteen years since I frequently warned the chemists, that they had scarcely ever obtained pot-ash very pure, very caustic, and well separated from all foreign matter, and possessing all the energy which characterises it when it is properly prepared. We are entirely ignorant of its characters, its real causticity, and all its distinct properties before the discovery of Black; and since this discovery, we long remained without giving it all its purity, all its causticity, without depriving it of all the carbonic acid which it generally contains, and without separating it entirely from the earths and salts which are so frequently combined with it. Citizen Berthollet was the first, who in 1787, described an exact process for obtaining this alkali very pure; and it was not

till subsequent to this period that its properties were discovered and described.

3. Pot-ash exists very abundantly in nature. It was at first extracted from vegetables by their combustion and incineration; chemists are still divided in opinion about its existence in plants; some imagine that it exists ready formed, and that it is only extracted by the action of heat; others believe that it is formed during the burning of vegetables, and while the ashes are strongly heated. It will be seen hereafter that the first opinion was apparently better founded than the second. Plants often afford a greater quantity of alkali, the more they are soft and herbaceous; more is generally extracted from tender than from hard wood; a much greater quantity is extracted from some plants than from others, and particularly more from the rind of fruits than from any other vegetable parts. Pot-ash is but seldom found in animal substances, and even then in very small quantities. M. Klaproth, of Berlin, discovered this alkali in Ventose of the fifth year of the French Republic, (March 1797) in several volcanic productions, even in a very considerable portion, that of 0,20: his discovery was afterwards confirmed at Paris by Citizen Vauquelin, and there is every reason to believe that it will be extended to a great number of other fossils.

Hence pot-ash is no longer an alkali peculiar to plants; it exists in minerals, and particularly in

in a great number of stones and earths, whence there is reason to believe it immediately passes into vegetables by their roots. It is never pure and insolated in natural substances, but always intimately combined, either with earths and in the stony state, or with acids, and in the form of salts.

4. Although the substances from which potash is extracted may not have been treated in the order which has been here adopted, it is nevertheless indispensably necessary to describe the manner in which this alkali is separated, as it would be ridiculous to speak of potash, which Nature never affords to chemists in a pure state, without indicating the means of preparing it. After having burned and reduced to ashes, wood, herbs, bark, wild fruits, tartars, lees, &c. which would answer no other purpose, the ashes are lixiviated, the leys evaporated to dryness, and the salt, which proceeds from it ignited in an oven or pots sufficiently heated. The produce of this operation is the potash of commerce; it is far from being pure. In order, therefore, to obtain it pure, it is mixed with double its weight of lime, and eight or ten times the total weight of the mixture of rain-water; this is boiled for two or three hours; the ley is then filtered or drawn off clear, and tried by means of lime-water, which it should not precipitate, otherwise it must be again passed over quick lime. This ley
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is evaporated in a cast-iron vessel, at a great heat, till it assumes the consistence of clear honey, at 50 degrees of cold. At this temperature some rectified alcohol is poured on at first, about one-third the quantity of the pot-ash employed: the mixture is well stirred, it is then heated and suffered to boil for a few seconds, after which the whole is poured into a jar, where it is left to cool. The matter separates into three layers; at the bottom the solid impurities are deposited; above these is an aqueous solution of carbonate of pot-ash, and at the top a liquor containing alcohol, and of a reddish-brown colour. This latter is decanted by a syphon, and is a very pure solution of pot-ash in alcohol; it is received in a basin of silver, or tinned copper; and evaporated rapidly, till, under a dry, black, and carbonaceous stratum, which is formed at the surface, there is seen a liquor of an oily appearance, in quiet fusion which coagulates and becomes solid by cooling; it is broken into fragments and inclosed in a phial.

5. Pure potash, thus extracted from the pot-ash of commerce, is a white solid body, susceptible of crystallizing in quadrangular prisms, which are compressed, very long, and terminated by pointed pyramids. These crystals, which are only obtained from very concentrated solutions, are soft, not durable, and very deliquescent. Their taste is so acrid, and their causticity so great, that they dissolve and soften
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the skin at the moment of touching it, and feels fat, and as it were soapy between the fingers. Pot-ash in this state, rapidly opens cauteries: in pharmacy also, where however it is not obtained so perfectly pure and caustic, it is called the *cauterising stone*. It dissolves and reduces into a saponaceous jelly, all soft animal matters; it changes green, and otherwise alters the colour of violets, by causing it to pass to a yellow-brown. Its specific gravity is not known, because it is impossible to weigh it without change.

6. Pot-ash does not act upon light. Exposed to heat in closed vessels, it becomes soft, and speedily liquefies; it takes the form of a clear mass, but opaque and granulated if suffered to grow cold. If the heat is continued, it becomes inflated, and is reduced to vapour when red-hot. On opening the vessel which contains it, it is seen to rise in a white smoke, which condenses upon cold bodies, and acts sharply upon the lips and nose when the vapour touches these parts: hence it is not a fixed alkali, as it was formerly called; or at least, it is only so comparatively to the fifth species. Thus volatilized, the pot-ash does not change its nature: it contracts a lightish-green colour like barites. This colouring is not owing to the earth of the crucibles, since it takes place in crucibles of silver or platina.

7. There is no action between pot-ash and oxygen gas, from which this alkali only carries off

off the water that it holds in solution; the same effect takes place with azote gas: thus the effect of air upon this alkali can neither be attributed to one nor the other of these bodies; but rather to the water and carbonic acid contained in the atmosphere. Pot-ash, on being exposed to the atmosphere, powerfully attracts its moisture, resolves entirely into a liquor, gradually absorbs the carbonic acid, which saturates it, and causes it ultimately to crystallize; it increases in weight, and thus becomes effervescent with the acids: to preserve it also very pure and dry, it is necessary to keep it in vessels exactly closed. Pot-ash, in this case, absorbs the water which is really dissolved in the air, and thus differs from the philosophical hygrometres, which only indicate the water that is precipitated; on this account, when plunged into water cooled to 10 degrees — 0, it becomes soft, and even then dissolves.

8. Pot-ash has no attraction for hydrogen; it neither absorbs nor separates it from any body, not even from the caloric which held it in solution under the form of hydrogen gas. It will only be seen hereafter, that by acting upon the compounds, which contain at the same time hydrogen and azote, it favours their reciprocal combination, and produces ammonia when the proportion of azote is sufficient; it is thus that it disengages an ammoniacal odour from all animal matters, and
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some vegetable substances, at the instant in which it softens and dissolves them.

9. We know not of any direct action between pot-ash and carbon. Charcoal does not dissolve in this alkali, either at a hot or cold temperature; but it is otherwise with carbon combined with hydrogen, which constitutes the oily state, as will be seen hereafter. The same effect, however, does not take place with carbon with respect to pot-ash, when it is once united with sulphur, as has been already observed, nor, perhaps, even with certain pieces of charcoal very much hydrogenated, of which it dissolves a greater or less portion, when strongly heated with them a sufficient length of time.

10. There exists but a very feeble attraction between pot-ash and phosphorus. These two bodies only unite when they are heated without moisture in a crucible, or a glass tube, as is customary with the phosphorated combinations. Volatilized phosphorus passes through heated pot-ash without combining with it. There is only formed a small quantity of phosphorated hydrogen, at the expence of the water contained in the pot-ash. Although these two bodies have but a small tendency to combine, yet by heating them both with water, phosphorated hydrogen gas is obtained in considerable abundance, and by this reciprocal action Citizen Gingembre first obtained this remarkable species of gas. It may here be perceived, that without any sensible union with the phosphorus,
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the pot-ash favours the decomposition of water by this combustible body, by means of its attraction for the acidified phosphorus. After the experiment a portion of phosphate of pot-ash is also formed, corresponding to that of the phosphorated hydrogen gas obtained. This decomposition is also aided by the attraction of the phosphorus for oxygen and hydrogen. The phosphorated hydrogen gas which is disengaged, proves that the phosphorated hydrogen forms no union with the pot-ash.

11. There is a much more powerful action between sulphur and pot-ash, than between this alkali and phosphorus. On triturating at a cold temperature, solid pot-ash and the third of its weight of sulphur in powder, in a glass or marble mortar, these two substances speedily become hot; the sulphur loses its yellow colour and acquires a greenish hue. A fetid smell is disengaged, resembling garlick. The mixture attracts moisture, and becomes soft: it is, at length, almost entirely soluble in water. If one part of sulphur in powder and two parts of pot-ash well mixed together, be heated in a crucible, the mixture melts long before it becomes red: by this process, sulphuret of pot-ash in a pure and dry state is obtained. This compound, which is so frequently employed, and which was formerly denominated *dry liver of sulphur*, or *liver of sulphur by the dry way*, is not generally prepared in this manner in the laboratories of chemistry and pharmacy. Long hereafter, on account of the scarcity and dearth of
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of very pure pot-ash, such as is here described, solid sulphuret of pot-ash will be prepared with this alkali, more or less impure. In general two parts of the pot-ash of commerce are melted with one part of sulphur in a crucible. The pot-ash employed, besides the earth and salts which it contains, is also saturated with carbonic acid; it is true, that at the moment in which it combines with the sulphur by fusion, this acid is disengaged with effervescence, and leaves the caustic, or pure pot-ash to combine with the sulphur. Thus this second process may be rigorously practised like the first; only it is necessary to take care that the mixture be not too strongly heated, that the sulphur may not be much volatilized, and to prevent the boiling occasioned by the too speedy disengagement of the carbonic acid in a state of gas. When the fusion of the substances is complete, the fluid compound is poured off upon a polished slab of marble, or porphyry: it is covered with an earthen lid, left to grow cold, and then broken in pieces, which are immediately inclosed in glass vessels, well stopped.

12. The solid sulphuret of pot-ash, thus prepared, is of a tolerably bright brown colour, nearly similar to that of the liver of animals, in consequence of which it formerly received the name of *liver of sulphur*. It quickly becomes green when exposed to the air, and at length changes to grey, and even to white: it is dense, and even vitreous on breaking, without any other

other smell than that of heated or sublimed sulphur : it is acrid and caustic, and leaves a brown spot upon the skin : its taste is likewise very bitter. By a strong heat in an earthen retort, it only gives out sulphur, and the pot-ash remains pure at the bottom of the vessel. All these properties take place only in these compounds when pure and recently prepared, but it is so little permanent, and so easily decomposed by the contact of the atmosphere, and particularly by water in vapour, and consequently by humid air, it is so ready to absorb water wherever it melts with this fluid, that sulphurated hydrogen gas may generally be drawn from it by distillation, unless when strongly heated for a length of time in the same vessel in which it was prepared. The sulphuret of pot-ash is very fusible ; it changes green, and destroys a great number of vegetable colours ; it reddens animal matters with less power however, than pot-ash alone. If it be heated dry with charcoal, it dissolves, and combines with it ; if treated with a dry acid, such as the phosphoric, boracic, and arsenical acids, in the vitreous form, it separates from the sulphur without any sulphurated hydrogen gas, and there remains a salt formed by the acid employed, combined with the pot-ash. All this is applicable only to the sulphuret of pot-ash formed by fusion, very recent, very solid, very pure, inodorant, and not changed by water or air.

13. Its properties, its attractions, and effects vary even at the instant at which the sulphuret of pot-ash touches or absorbs water, and as soon as the alteration which it undergoes adds hydrogen to its composition; at that time the brown colour changes to green; its sulphureous smell is succeeded by an insupportable fetidness, resembling the well-known stench of rotten eggs, or that of stones which have long remained at the bottom of a common sewer. It becomes susceptible of giving out sulphurated hydrogen gas by distillation with acids: the latter, when employed in a liquid state, suddenly effect the same changes in the sulphuret of pot-ash. When sulphurated hydrogen gas is desired, it is rapidly obtained in considerable quantity, and by a quick effervescence, by throwing upon the sulphuret of pot-ash in powder some muriatic acid, in the pneumato-chemical apparatus. It will readily be seen that these effects are owing to the sudden decomposition of the water, effected by the sulphuret of pot-ash. On dissolving this compound in water, the attraction which pot-ash has for the oxygenated sulphur, or the sulphuric acid, acts by disposing affinity; the water is decomposed; its oxygen is conveyed to the sulphur, while another part of this body combines with the other principle of water, hydrogen, and the force of this second combination unites with the first to effect the decomposition of the water. This sulphurated hydrogen combines with the sulphur and the alkali, and forms an hydrogenated

genated sulphuret of pot-ash. Although we are still ignorant of the respective attractions of the different earthy bases for sulphur, compared to that of pot-ash for the same combustible body, we know, however, that barites, lime, and strontian, decompose the sulphuret of pot-ash, and take possession of the sulphur.

14. Sulphurated hydrogen gas, being very different in this respect from phosphorated hydrogen gas, readily combines with pot-ash; when this gas is passed into a solution of alkali, it is absorbed and condensed; it saturates pot-ash, and forms the compound which Citizen Berthollet was the first to describe, and which he denominated *hidro-sulphuret of pot-ash*. This compound crystallizes, and is more permanent than the sulphuret of pot-ash; its crystals are transparent, while the sulphur is brown and opaque. Heat and the acids decompose it, and disengage sulphurated hydrogen gas without precipitating sulphur from it. The oxygenated muriatic acid decomposes the sulphurated hydrogen, and separates sulphur. Several metallic oxides also produce the same effect, and hence the reason why they suddenly take away the smell from the hydrogenated sulphuret of pot-ash. It is also necessary to observe here, that very pure hidro-sulphuret, without any sulphur foreign to the saturation of the hydrogen, has no odour, and that alkali appears to have more attraction for sulphurated hydrogen than for sulphur; that likewise when it is saturated with the former, that

is to say, when it is in the state of crystallizable and inodorous hidro-sulphuret of pot-ash, it cannot take any more sulphur; whereas, on the contrary, when sulphurated hydrogen gas is passed into a solution of sulphuret of pot-ash already hydrogenated by the mere circumstance of its solution in water, as I have shown, at a certain degree of saturation the sulphurated hydrogen acts in the manner of the acids, precipitates the sulphur like them, discolours the liquor, decomposes all that is sulphuret, and at last brings the alkali to the state of mere hidro-sulphuret of pot-ash.

15. These ideas readily tend to explain what takes place when sulphur is united with alkali dissolved in water, or when, as was said before, the *liver of sulphur* is prepared in the humid way. It will be seen that a simple sulphuret of pot-ash only is fabricated in this way. Two parts of pot-ash, one part of sulphur, and six times the total weight of this mixture of pure water, are put into a matrafs, the mixture is heated on a sand bath; the action already begun between the pot-ash, the sulphur, and the water, by the heat produced at the moment of the union of the caustic alkali and the water, continues and increases by the accumulation of caloric; the liquor assumes a yellow colour; the sulphur apparently dissolves with the alkali; a slightly fetid smell is discharged; the colour and fetidness gradually increase; an hydrogenated sulphuret of pot-ash is obtained, which,
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by the continued action of the substances of which it is composed deposits sulphur, at length loses its colour, and becomes a pure hydro-sulphuret of pot-ash without any smell, because the sulphurated hydrogen is united with it by the pot-ash, whereas being less adhesive in the sulphuret, it has a tendency to disengage, and to take the gaseous form, which causes the fetidness of these compounds.—What has been here said respecting the greater attraction of sulphurated hydrogen for pot-ash than that of sulphur for the same alkali, and of the decomposition of the sulphuret of pot-ash by sulphurated hydrogen, applies equally to the similar combinations of sulphur with lime and barites.

16. Pot-ash has no action upon the diamond, neither in the dry way, nor the humid way, nor upon most of the metallic substances. The few effects which take place between some metals and pot-ash depend on the water, the alkali of which, by a disposing attraction favours the decomposition by these combustible bodies. In this case the metals are oxidized; there is a disengagement of hydrogen gas, and a more or less intimate combination between the oxides thus formed, and the pot-ash. Thus it may be imagined, that rust is much sooner produced on some metals plunged in alkaline lees, than on the same metals simply soaked and covered with water.

17. Water is one of those bodies for which pot-ash has the greatest attraction. When this
alkali

alkali is mixed in powder with the fourth of its weight of ice congealed at 0, there is almost an immediate fusion of the ice and the solution of pot-ash; the caloric absorbed by the liquefied bodies, causes the thermometer to fall several degrees below 0; which evidently depends upon the quantity of water of crystallization contained in the pot-ash, and that instead of condensing the water of solution, and expelling its caloric, as would be the case if the alkali were perfectly dry, it only dissolves, as a crystallized salt would have done, and then requires an absorption of caloric to become liquid. Some modern chemists employ a mixture of crystallized pot-ash and ice, for the purpose of producing artificial cold, useful in some experiments; but this method has the inconvenience of being very expensive, on account of the extreme dearth of the alkali. There are other means much less costly, which I shall describe.

Liquid water at ten degrees of temperature dissolves, with much energy, pot-ash well dried and recently prepared. When this pot-ash is thrown in powder into water, the alkali begins by absorbing a part of the liquid, and by forming, at the bottom of the vessel, a solid mass, in a piece: which effect takes place at the commencement of all the solutions of solid bodies, even that of sugar in water. Very soon, however, and particularly by the aid of agitation, the water penetrates, and separates the particles from the mass which melts in this liquid. Half

a part of water is sufficient for liquefying one part of pot-ash. In proportion as this solution takes place, caloric is disengaged, and the liquid which is formed possesses a considerable density. The heat which is developed during the solution, is sufficient for driving off a little pot-ash with the water in vapour: hence the smell of the ley which is exhaled, and the property which this vapour possesses of changing paper green with is tinged with mallows. The same phenomenon has been observed in the extinction of lime. The solution of pot-ash is colourless when it contains no vegetable or animal substance: it is clear, transparent, and leaves no precipitate. To separate the pot-ash from its solvent, it is customary to recommend the liquor to be evaporated in closed vessels, lest it should attract the carbonic acid of the atmosphere. But this does not succeed in glass vessels, because liquid alkali attacks glass, and because when the liquor is dense it forms bubbles, which are agitated and frequently cause the vessels to break, and, in short, because solid pot-ash adheres so strongly to glass, that it cannot be detached from it. On evaporating it very rapidly in the air, as has already been said, the strong vapour which arises prevents the absorption of the carbonic acid.

18. Liquid pot-ash unites with several metallic oxides, which it renders soluble in water, and which saturate it in the manner of acids, such as those of antimony and zinc: some others undergo

dergo a flight change in their nature by its contact, and approach to the metallic state on losing a portion of oxygen, such as the green oxide of copper; but there are some which absorb a greater quantity, as the oxide of manganese. It was imagined that a means of decomposing this alkali could be found in the action of metallic oxides upon pot-ash; and the formation of nitric acid was supposed to be perceptible, and consequently the presence of azote in pot-ash to be proved: but this result was not obtained by Citizens Vauquelin and Hecht. Hence the reason, why I have already said that there is no fact which proves, with certainty, the presence of azote as the alkaligen in the fixed alkalis.

19. All the acids, with the exception of the oxygenated muriatic, readily combine with pot-ash, and form with it salts which will be attentively examined in the following section. It will here be sufficient to state the order of the attractions of pot-ash for the different acids; and the analogy of such attractions with those of other salifiable bases for the same bodies. Experience has proved that, with respect to their adherence for pot-ash, the acids ought to be placed in the following order, beginning with the strongest: the sulphuric, nitric, muriatic, phosphoric, phosphoreous, fluoric, sulphureous, boracic, nitrous, and carbonic acids. As to the place which pot-ash holds, compared with the other acidifiable bases, it is always after barites, most frequently before lime, always before stron-

tian, ammonia, magnesia, glucine, alumine, zircon, and flint.

20. Pot-ash combines with flint by the dry way, and dissolves it by fusion; it then forms a transparent body, known by the name of glass, which varies in its nature according to the proportion of sand and alkali. Two or three parts of pot-ash to one of flint form a brittle glass, deliquescent in the air, soluble in water, the solution of which formerly bore the name of *liquor of flints*, and which is, at present, denominated silicated pot-ash. It deposits, after a length of time, the earth which it contains, often in soft and gelatinous flakes; the acids decompose it, by taking possession of the pot-ash, and separating the earth from it, under the form of white and very fine powder, which when well washed, is pure flint. Sometimes, if the solution be diluted with a quantity of water, and much more acid be added, than is necessary to saturate the alkali, the flint remains in solution, particularly in the muriatic acid; but it is precipitated from it by the action of caloric alone. Thus deposited, the flint is still unchanged; and it is by an error, which originated from a solution of part of the earth of the crucibles by alkali, that it was formerly supposed to be in part converted into alumine by the action of the pot-ash. Glass differs from silicated pot-ash only by a greater proportion of flint. The art of making it consists in the choice of pure sand, as well as pot-ash, their proportion, their complete fusion
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by means of a sufficient heat, and long enough continued to have no bubbles, veins, nor threads, and so that it shall be transparent, very hard, and unchangeable in air. A small quantity of alumine, lime, and certain metallic oxides are often added, to render it more hard and homogeneous, of a more equal fusion, of a more perfect transparency and whiteness. It is on account of this evident action upon filex, that pot-ash is employed for analysing hard stones, as I shall elsewhere explain. Liquid pot-ash also attacks glass in so sensible a manner, that when preserved for a length of time in bottles and decanters, it corrodes and destroys them, and thus becomes loaded with filicated earth.

21. The action of this fixed alkali upon alumine is still stronger than upon filex; it dissolves it by the dry and the humid way; it is better saturated with it, dissolves more of it, and loses more of its own properties in this union. It even appears that alumine decomposes filicated pot-ash. By the dry way, alumine melts into a more or less opaque frit, with pot-ash; a certain dose of filex being added gives it transparency. Liquid pot-ash abundantly dissolves alumine diffused in water, and takes up a great quantity of it. It is by this strong action that alumine differs from filex. This property may even be employed for separating the former from the latter, and particularly from other earths which are much less soluble in pot-ash than filex.

22. Pot-ash has no action, no solvent property upon zircon. These two bodies when heated, do not combine; they do not melt together; the melted pot-ash remains separate. This inaction is taken advantage of, for separating alumine and silica from zircon in the analysis of stones. The perfect insolubility of zircon in pot-ash, is one of the distinctive characters of that earth. It is the same with glucine as with zircon, with respect to its insolubility in pot-ash.

23. There is no attraction between pot-ash and the two alkaline earths. Magnesia and lime do not, in any manner, combine with pot-ash, either in the dry or the humid way. This alkali, therefore, becomes a very useful re-agent for separating either silica or alumine from those two earths, when they are mixed or combined together.

24. Though I have observed that the nature of pot ash is not known, and that a few ideas only were entertained relative to its intimate composition, I ought not to omit mentioning, in this place, a fact, perhaps illusory, since I have only seen it once, and in the small way, which is capable of directing us in a way to arrive at a more certain result. Having exposed liquid hydrogenated sulphuret of lime in a receiver, to atmospheric air, I found the air ameliorated after some hours, and containing less azote gas, and more oxygen gas, and the sulphuret at last afforded me traces of pot-ash:
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such is the origin of the opinion which I long ago proposed, as to the composition of this alkali by lime and azote. But I ought to observe that as this assertion can only yet be considered as a suspicion, and not as a verified fact, I here only mention it, in order to induce chemists to profit by the opportunities they might have of confirming or refuting it.

25. Although we are ignorant of the composition and principles of pot-ash, the properties that have been discovered in it, most of which I have already described here, have rendered it one of the most useful instruments to chemists, and have much influence on the principles of the science. It is one of the most important agents in a great number of modern analyses as will be seen in the sequel; it guides the steps of mineralogists in the classification of stones, by the facility with which it is employed in their decomposition.

In medicine it is one of the most important and powerful medicines which can be employed, as a solvent, caustic, lithontriptic and asthenic: its effects which are sometimes too active sometimes even poisonous, are quickly destroyed by the acids, oils, and fatty substances.

It renders a number of services to the arts of glass-making, bleaching, soap-making, docimacy, the purification of salt-petre, paper-making, printing, painting, &c. Its application will be shown as an opportunity shall be afforded hereafter. It will be sufficient to state here in

in general, that pot-ash, so useful to men in a state of society, and which contributes in so many ways to their welfare, ought to be used and considered as a very precious article in countries where there is not much wood; and that means ought to be taken to restore it after the use to which it has been destined, that it may not be lost, as is too often the case; and to give it again, by evaporation and calcination, the same form and the same activity which it possessed before it was employed. This economical practice ought not to be neglected in the trades and manufactures, where there is a great consumption of pot-ash, and where it is an article of considerable expence.

ARTICLE II.

Of Soda.

1. THE name of soda, like that of pot-ash, is adopted in commerce: it denotes that species of fixed alkali which is extracted from the marine plant, called *kali* or *soude*, in French. This alkali was formerly called *caustic mineral alkali*, *marine alkali*, *ley*, or *liquor of soap-makers*, because it was supposed to be more abundant than the other among minerals, and because it forms

forms a part of marine salt, and is preferred to pot-ash in the preparation of soap. In order not to confound the soda which I am to describe here, or soda in its state of purity, with the impure alkali mixed with a number of substances, and combined even with an acid, such as it is prepared in the large way, for the purpose of the arts, and which is afforded in commerce, —the word soda alone will be employed for the first, and the latter will be denominated soda of commerce.

2. Soda, as a species of fixed alkali different from pot-ash, has only been discovered and distinguished from the latter since the middle of the eighteenth century. After having been pointed out in the ninth century by Geber, the Arabian, it was so confounded with the alkali extracted from common plants, that in 1750 the salt, formed by art with the muriatic acid and pot-ash, was called *regenerated marine salt*. Pott, Margraff, and Duhamel, destroyed this confusion, and made a proper distinction between these two alkalis, since the period alluded to. But pure soda was still unknown, though it was distinguished from pot-ash, before chemists were convinced that it was rendered mild, and saturated by an acid in its state of commerce, and that it is necessary to deprive it of this body, to obtain it pure and insulated. The character also of causing effervescence with the acids, was likewise given to it, as well as to pot-ash, before the carbonic acid was known; though it is necessary to deprive

prive it of this acid, and to take away its effervescent property, in order to have it pure. Nor was the difference between the attractions of soda and those of pot-ash known before the inquiries of Bergmann. All this information being once acquired, no farther obscurity remained as to this species of fixed alkali.

3. Soda exists native like pot-ash, but not more pure or insulated than the latter: it is always combined either with the different acids, particularly the muriatic, carbonic, sulphuric, and phosphoric, in the interior parts, or at the surface of the earth, in fossil salts, in the waters of the sea, and saline springs, or in vegetable or animal juices. That which, combined with the carbonic acid, so frequently and abundantly presents itself, in the form of saline efflorescence, at the surface of the earth in Egypt, or the plains of the Delta, irrigated by the waters of the Nile, upon old subterraneous walls, ruins of buildings, &c. is the most pure; it is only necessary to deprive it of the carbonic acid it contains to extract soda in its perfect state. The enormous quantity which Nature has placed in the salt of the sea and of saline springs, is more difficult to be separated, though this point has been gained by art, by the assistance of several processes, which will be described hereafter under the article of this salt. The soda most generally employed at present, is extracted from several plants which grow in the sea.

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4. It is the genus of vegetables denominated *falsola* by Linnæus, and particularly the species called *foda*, which grows washed by the sea water, that furnishes this kind of alkali. This plant, when examined by Citizen Vauquelin, afforded foda combined with a vegeto-animal substance, which it was necessary to destroy by the action of heat. After having been collected in heaps on the banks of the sea, and left to dry by the contact of the air, it is burned, and the ashes are calcined sufficiently to cause vitrification to begin, care being taken to agitate it in the air, in order to destroy as much of the carbonaceous matter as possible. When cooled, these ashes, being well calcined, and half vitrified, present solid masses of a greater or less size, of a bluish or blackish-grey colour, dense or porous, of a saline, acrid, and bitter taste, mixed with charcoal, stones, and flints, and containing, besides the foda almost saturated with carbonic acid formed by the combustion of carbon, a variety of salts, oxide of iron, some alumine, silice, and different foreign bodies. The best foda of commerce, however, is that made at Alicant, as it contains most alkali. In other maritime vicinities, and particularly at Cherbourg, and on the coasts of the *ci-devant* province of Normandy, they burn and calcine in the same manner, the algas, fucus, varechs, and several other marine vegetable productions, which afford an ash much less rich in foda than that of Alicant: it is known in commerce, by the

the name of foda of Cherburg. These alkaline and impure ashes of commerce, are also indifferently, and very improperly called *salicot*, *salicorne*, *alun-marie*, *alun-catin*, &c.

5. These kinds of foda of commerce, are very impure, and much mixed, though fit for many uses in the arts; that which is even far more pure and rich in alkali, which is extracted from marine salt, by the processes that will be pointed out in the history of this salt, ought to be treated by the same chemical means as pot-ash, to be brought to the state of pure foda. The fodas of commerce are washed with cold water, the leys are evaporated to dryness in vessels which cannot communicate to them any thing of a foreign nature; and the salt obtained by evaporation, which when it has been well prepared, is scarcely any thing but foda, saturated with carbonic acid, is then mixed with quick-lime. The mixture is diluted with water, and strongly agitated; this second ley is evaporated, and some alcohol is added: the portion dissolved by this inflammable liquid is separated from foreign bodies, and particularly from the aqueous liquor which is below it; this solution with alcohol is then evaporated; and after taking off the thick and carbonaceous crust which is formed at the surface, the liquor is then brought to the state of a thick and an unctuous oil, remaining in a tranquil solution, and becoming solid by cooling: this is poured off into vessels of pottery, or porcelain, where it is left to congeal, that it
may

may be afterwards broken, and enclosed in well-stopped bottles. It will be seen, that this is absolutely the same process as that pointed out for the extraction and purification of pot-ash. It consists in depriving the soda, first separated from foreign bodies by cold water, of the carbonic acid which saturates it, by means of the lime, and dissolving it alone, and without any mixture either of earths or other salts, by alcohol, which on dissolving it, separates even from the portion of water that holds the portion of carbonate of soda and salts that have escaped, and lastly, in volatilizing the latter solvent, to obtain soda very pure, in the solid, and even crystalline form.

6. Soda thus purified and extracted, is commonly in the form of solid plates, of a greyish-white colour, a burning causticity, and an urinous taste, like pot-ash. Like the latter, when its alcoholic solution is evaporated, it takes the form of prismatic and elongated crystals, of a soft consistence, and retaining much of the water of crystallization: the difference between which and those of pot-ash has not yet been exactly determined, though it is well known that they have not the same primitive figure; they are, besides, so changeable and so little permanent, that they alter even while under observation. Soda acts with much activity upon animal substances and dissolves them. It changes the blue colour of violets, and

and turns to number of other vegetable colours green.

7. Light exerts no action upon foda. Caloric softens and quickly melts it: it liquefies by heat like an oily substance, boils, and is reduced to vapour when ignited. This vapour is merely foda without alteration; it is acrid and cauterises the skin. In a silver crucible, foda when long heated, acquires a greenish colour; to whatever degree of heat it may be exposed, it does not change its nature; it appears to be a little more fusible than pot-ash.

8. It has no action upon oxygen in a state of gas, or combined with burned bodies, nor upon azote; when moistened only with the water, which it acquires from those two gaseous bodies, it does not change either their nature or their properties. Soda, like pot-ash, when triturated with substances containing azote combined with hydrogen, favours the binary combination and the formation of ammonia, by uniting itself with the remaining parts of these substances that have become more or less oleaginous, as will be accounted for hereafter, relative to its action upon animal matters. In air, without acting upon the oxygen and azote gases, foda only absorbs the water that is dissolved in it, and the carbonic acid that is mixed with it; it becomes moist and soft, but does not liquefy intirely like pot-ash. It never forms any thing in the atmosphere but a kind of soft paste, which dries on being exposed for some days to the air, when
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the air itself becomes dry; at this period the foda, whitens, dries, crystallizes, and effloresces. This is a consequence of the absorption of the carbonic acid of which it requires much less to saturate it than pot-ash. We may, therefore, by the mere phenomena which attend their exposition to the air, distinguish foda from pot-ash. It may thus also be seen, that in order to preserve foda pure, it must be kept in well-closed vessels.

9. Hydrogen and carbon, each in their insulated state, have no attraction for foda, which does not act either upon the former in a state of gas, or upon the latter when solid, at whatever temperature they may be exposed. It appears, however, susceptible of combining, in some instances, with carbonated hydrogen, as will be seen hereafter. It does not combine more sensibly with phosphorus, and no phosphuret can be formed either in the dry or the humid way. When phosphorus is heated in a ley of foda, there is only a formation and disengagement of phosphorated hydrogen gas, which separates, as will be seen, without combining with the alkali; this inaction resembles that which has been observed in the history of pot-ash.

10. Sulphur easily combines with foda by simple trituration, by fusion, and in the humid way. In the two first instances the caustic sulphuret of foda is formed, which is decomposable by heat, by the acids, and decomposes water like
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the sulphuret of pot-ash ; in the third, a fetid hydrogenated sulphuret is obtained, from which sulphurated hydrogen gas is disengaged by the acids. All that has been said upon this kind of sulphurated alkaline combination under the articles of barites and pot-ash, upon the difference between sulphurets made in the dry and those made in the humid way, of pure, compared with hydrogenated sulphurets, of the decomposition of sulphurets, and the precipitation of sulphur by sulphurated hydrogen gas, must be applied here, and joined to the properties of soda already known. There is a perfect parity between these three alkalis when very pure, with respect to their comparative action upon sulphur, and the various compounds they are capable of forming with this combustible, and nothing can be added to what has been said in the articles of barites and pot-ash. Soda combines equally with sulphurated hydrogen gas, condenses and absorbs it, forms with it a crystallizable hydro-sulphuret of soda, which is colourless, inodorous, soluble, more permanent in the air than the simple sulphuret and the hydrogenated sulphuret, decomposable by the metallic oxides and the acids, which separate it frequently in crystals from the liquid hydrogenated sulphurets, and which, though analogous to that of pot-ash, nevertheless differs from it by some individual properties. Soda appears to have less attraction for sulphur and sulphurated hydrogen than pot-ash, and particularly less than lime and barites.

11. The action of soda upon the diamond, and upon metals, is absolutely none. When it is united to water, it facilitates the decomposition of that oxide, by some metallic substances; it gives rise to the disengagement of hydrogen gas, and to the oxidation of those metals, of which it then dissolves a portion of the oxides.

12. Soda has a strong attraction for water. If this alkali when very dry, be moistened, it absorbs, and renders the water solid with activity, disengaging from it a quantity of caloric. By adding more water than it can absorb or solidify, it dissolves with heat, and the disengagement of a lixivial odour, owing to a portion of soda which is raised in vapour with the volatilized water. We are assured of this latter fact, by exposing to this vapour paper tinged with mallows or turmeric; the former is changed to green; the latter passes by its contact from yellow to a reddish-brown. A thick solution of soda affords, when left to cool, after having been rapidly heated and evaporated, elongated and soft crystals. Soda cannot be obtained pure and solid from this solution, except by evaporating it at a great heat in a basin of silver, or tinned copper; the very abundant aqueous vapour which then arises, really takes off the contact of air, and opposes itself to the absorption of atmospheric carbonic acid. To preserve this solution of soda very caustic, it ought to be kept in glass vessels well stopped; it, nevertheless, acts upon the substance of glass, which it corrodes

and renders very brittle by the changes of temperature. I have many times seen glass bottles in which leys of caustic pot-ash, or soda, were inclosed, and left upon a certain quantity of quick-lime to ascertain its causticity, crack horizontally at the lower part near the bottom, constantly in the same place, and thus let out the fluid they contained.

13. Soda combines with certain metallic oxides which saturate it in the manner of acids. There are some of which it seems to favour the disoxidation; others appear, on the contrary, to acquire by its contact, a stronger tendency to unite with oxygen. This reciprocal action, therefore, singularly varies, according to the difference of the metallic oxides, their various states of combination with oxygen, and their attraction for this principle; it will be spoken of under the history of metals. This is, however, the same phenomenon as takes place with pot-ash. It has been expected, but this expectation has not yet led to any useful result, that the metallic oxides might serve to explain the constituent principles of soda, by effecting its analysis: but hitherto this has proved only an illusion, as it has with pot-ash.

14. All the acids, except the oxygenated muriatic, readily combine with soda. From this union salts are produced, which will be examined in the following section. The order of attractions of this alkali for the different acids is the same as that of the attractions of pot-ash for the same bodies. They are, in general,
weaker

weaker than those of pot-ash, which separates soda from all the saline compounds of which it forms a part. Soda, therefore, ought to be placed immediately below pot-ash, and consequently in the second rank below barites in the table of their mutual and comparative attractions for the acids.

15. Soda combines very easily with flint by the dry way, and converts it into glass: it even dissolves this earth by fusion with more facility than it is dissolved by pot-ash: it is, therefore, preferred by glass makers. The notions which have been given relative to the nature and fabrication of glass, under the article of pot-ash, must be applied here. It will only be necessary to add that soda, or the fixed alkali in general, which is engaged in this vitreous combination with flint, not only loses its deliquescent soluble property, &c. but it is also very difficult to be separated from it by the acids, since the latter, when contained in vessels of glass, only alter it in a very small degree, and because they must long be left in contact, and even made to boil over glass reduced to very fine particles, in order to prove the presence of alkali in that compound, and particularly to ascertain its quantity. Soda dissolves flint when well pulverized, even in the humid way, like pot-ash, and the earth is separated from it by means of the acids.

16. Alumina is also readily attacked and easily soluble by soda: it is more soluble by

soda than flex is by pot-ash; and it has a greater attraction than the former earth for the two fixed alkalis. Soda may, therefore, be employed like pot-ash for dissolving and separating alumine from glucine and zircon, as soda does not dissolve these better than pot-ash does. By these properties, it may serve, like the latter, for the analysis of stones.

17. Soda has no attraction for the two alkaline earths, and forms no union either with magnesia or lime; it does not act upon them either in the dry or humid way; it has more attraction for the acids than those alkaline earths; from which it completely separates them.

18. There is no known action between soda, barites, and pot-ash; they mix, however, and are confounded by fusion, and by solution in water; but on exposing this solution to the air, the barites, which forms dry pellicles at the surface, may be separated, and on evaporating the residuum to dryness, the pot-ash may be obtained in an insulated state, which liquefies in the air while the soda dries in it. The acids are employed with still more advantage for this separation, on account of the different salts that the three alkaline bases make with those bodies, and of the various degrees of crystallizability and solubility of those salts, &c.

19. If we compare the properties of soda with those of pot-ash, it will be found that in their state of purity or insulation, there are the greatest and strongest analogies between them,

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and almost the same as is observed between barites and strontian. There is scarcely any fact but the non-deliqescence and the want of softening in the air, by which it can be distinguished from pot-ash; much practice in experiments with these two alkalis is also necessary, in order to learn how to distinguish them, unless they are combined with the acids, and their saline compounds examined, which afford very sensible differences between them.

20. The intimate nature of soda is no better known than that of pot-ash. Some facts and analogies have induced me to think, for several years past, that soda is formed of magnesia saturated with azote. My opinion, in this respect, principally rested upon the constancy with which this earth accompanies soda in waters and the various compounds of which that alkali forms a part, particularly in animal matters and marine products. Citizen Vauquelin found magnesia in abundance in the ashes of the *Salsola soda*. Several chemists have adopted my conjecture. Lorgna has given a particular description of a series of experiments, from which it appears, that a great quantity of magnesia may be obtained during the extraction and purification of soda. But I ought to add, that no fact direct or positive, no experiment synthetical or analytical, has hitherto proved this assertion. I ought also to observe that, for my own part, I consider it only as an hypothesis, which ought not to be confounded with the exact acquisitions of science.

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21. The precise knowledge of soda, particularly since the late discoveries of modern chemists, since the art of bringing it to a great degree of purity unknown to philosophers till the period when Citizen Berthollet described the use of alcohol in this preparation, have already had, and will continue to have a very great influence on the progress of the human mind. The part that soda acts in chemical phenomena has certainly extended, and cannot fail still farther to extend a light which must contribute, in a singular degree to the progress of science, and equally conduce to the perfection of the chemical arts. Few chemists, however, have yet prepared and examined pot-ash, or soda very pure, and most of them still daily take for these alkalis, impure matters which retain carbonic acid, filix, alumine, and salts, and which consequently have not all the energy or activity of those alkalis. They are, also, still unacquainted with the methods of obtaining every possible advantage from this agent, notwithstanding the important means of analysis which it affords.

22. Soda may be used for the same purposes as pot-ash, and may be employed like it in the arts. Accordingly it is frequently used as a substitute for pot-ash. It acts, like the latter, upon animal substances, is externally caustic, and internally solvent and lithontriptic; it is made use of in medicine for the same indications. It even appears to be preferable to pot-ash

ash as a medicine, on account of its analogy with animal substances, which always contain it, while, on the contrary, no portion of pot-ash is found in them. Some physiologists have imagined that the pot-ash, contained in all alimentary vegetables, is converted into soda by the process of animalization; but this idea is not yet confirmed by any accurate experiment.

Soda is employed in many of the arts. It is particularly useful in the manufacture of glass and soap, in leys, dyeing, and the preparation of Prussian blue, lacquers, and paper. It is often preferred to pot-ash in most of the manufactures, because it is milder, much less acrid, and is not capable like that alkali of attacking, or weakening, the texture of piece goods, or of corroding and destroying utensils of wood, metal, &c.

ARTICLE XII.

Of Strontian.

A FEW years ago, when the properties of strontian were discovered, and this substance was distinguished from barites, with which it had at first been confounded, its analogy with the latter, nevertheless, made such a forcible impression, that they were placed together in
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all methodical works, and chemists were contented with merely pointing out the slight differences between them. A more profound investigation of its properties and chemical characters, having confirmed, in my mind, its similarity to barites, and induced me to withdraw it, like the latter from the order of earths, in order to arrange it among the alkalis, has also required, in consequence of the method I had made choice of, that I should place it after soda, on account of its general order of attraction for the acids. The diversity of the chemical attractions appears to me like that of the specific gravities, to place bodies at a still greater distance from each other, than the analogy of several other kinds of properties appears to connect them.

2. The name of strontian has been given to this species of alkali, from that of strontianite, which Sulzer, the mineralogist of Roneburg, had assigned to the saline stone from which it was extracted, and which was first discovered at Strontian in Argyllshire, in the North of Scotland. As it has already been well ascertained that Nature has not placed this alkaline base in one place only, and that there is reason to believe its saline combinations may be found in many countries, like those of barites, with which it has so much analogy, it were to be wished, that it had been distinguished by a denomination different from that of the place where it was first discovered, a denomination expressive of its properties. But the word
strontian

strontian being already known and adopted in Europe, I have not thought proper to change it, as I know of no more appropriated denomination that could be substituted.

3. Strontianite, or the fossil which furnishes strontian, has been for some time confounded with witherite, a natural compound of barites and carbonic acid, which was first made known by Dr. Withering, and for some time bore his name (*witherite*). M. Klaproth, of Berlin, first distinguished it from the carbonate of barites, and discovered that it contained what he denominated an *earth*, different from the latter. This discovery was announced in Crell's Annals, at the end of the year 1793, or about the beginning of 1794. A short time after, Mr. Hope, a chemist of Edinburgh, the successor of Dr. Black, laid before the Royal Society of that city, a very elaborate work on the properties of the strontianite, in which he compared it to barites. The earliest notions which were received in France on this subject, first induced the French chemists to imagine that this base was not different from barites; but Pelletier, Citizen Vauquelin, and myself, having occasion to examine it, were convinced, that notwithstanding the very remarkable connection with it, it ought nevertheless to be distinguished, and admitted as a particular substance.

4. In order to obtain strontian, its natural combination with the carbonic acid is decomposed,

posed, by calcining it by heat, after having mixed it with charcoal, and washing the residuum with water, which dissolves the calcined strontian; or by dissolving this native salt in the nitric acid, and expelling this acid by a strong heat, which at last leaves the strontian pure in fragments, melted or softened; or by precipitating the solution of the same salt in the muriatic acid, by the fixed alkalis which separate it from them, which is not the case with barites, as will be seen in the following article. In this third operation, it is in the form of a white powder, but it contains water between its particles, and is neither so pure, nor so acrid, as that which is produced by the decomposition of the nitrate of strontian by heat.

5. In those places, where Nature affords only the sulphate of strontian, as at Paris, where it has just been discovered in abundance in the roads of Montmartre, this salt is decomposed with charcoal by means of heat, and is thus converted into sulphuret of strontian which is dissolved in water; this solution is precipitated by the nitric acid; the nitrate of strontian is evaporated in order to dry it, and it is then decomposed in closed vessels. It has also been proposed to decompose the sulphate of strontian, by boiling it with a solution of carbonate of soda or pot-ash, by dissolving with the nitric acid the carbonate of strontian, which is formed, and remains at the bottom of the liquid.

quid in a white powder, after having been washed, and by evaporating this solution to dryness, in order afterwards to decompose the nitrate of strontian by heat. I believe this alkali might be obtained still more simply, by treating the native sulphate of strontian by solutions of barites, pot-ash, or soda. The first will even have the advantage of speedily obtaining the strontian separate in solution in the water, because the sulphate of barites which is formed, will remain in an insoluble powder at the bottom of the liquor.

6. Pure strontian, hitherto obtained only by the action of heat, which decomposes its nitrate, is in fragments, or pieces of a whitish-grey colour, often porous, of a hot, acrid, alkaline, or urinous taste, more powerful than that of lime, but less burning than that of barites, pot-ash, or soda; its specific gravity is rather less than that of barites, but evidently greater than that of pot-ash and soda. Its weight, however, is sufficiently analogous to that of barites to suffer it to be confounded with this last alkali. It acts but feebly upon the skin and animal matters. It very strongly changes to green, violets, mallows, the rind of radishes, and in general, all vegetable colours susceptible of taking this tint by the action of alkaline matters.

7. Light exerts no sensible action upon strontian, though there appears to be a particular attraction between those two bodies, as the phospho-

phosphorescent property about to be described appears to indicate. On being heated in a vessel of infusible metal, such as a vessel of platina, it may be kept a long time ignited, without undergoing any change, either in its appearance of fusion, of volatilization, or sublimation. In a porcelain retort it contracts a greenish colour, as does barites, particularly at the part which touches the retort. When treated in the small way by the blow-pipe, it does not melt like the latter, but is penetrated by light, and is surrounded by a white flame, so brilliant that the eye is affected by it similar to the injury it receives by the aspect of the sun. It may be said, on examining with attention this beautiful phenomenon, that strontian has the property of fixing and condensing light. We must not attribute to pure strontian the property of forming by fusion a white and opaque glass; as is, in fact, the case with strontianite, or the native carbonate of this, and also with that of barites when urged by flame before the blow-pipe.

8. There is no attraction between strontian and oxygen; it does not absorb it from oxygen gas, which it does not alter, nor from any other burned body. It is the same with azote, as it does not absorb azote gas, nor does it separate it from any of the bodies which contain it. From these results relative to the two gases which constitute common air, it is evident that it is neither upon one nor the other of these gases, but upon the water and carbonic acid gas that strontian acts, when it is kept

kept immerfed in it; fo that the effects about to be defcribed are the more speedy and energetic as the air is more humid, as the water is lefs intimately combined, and as it contains more carbonic acid gas. When expofed to the air, very cauftic ftrontian fwells, bubbles, divides, becomes hot, and is converted into a white voluminous powder, which is no longer acrid, nor has it the property of heating or boiling with water. Thefe effects are lefs quick and energetic in ftrontian than in barites only, which affords them with much more activity. Thus efflorefced and extinguifhed, the ftrontian is found to have increafed in weight by the water which it has abforbed. At the expiration of fome days it is loaded with atmospheric carbonic acid, and becomes efferefcient. It is worthy of remark here, that this property which announces a very ftrong attraction between atmospheric water and ftrontian, which appears to be common to ftrontian and barites, and confequently to authorife the analogy that has been eftablifhed between them, is not to be met with in pot-afh and foda, though they are likewise fimilar in other refpects; fo that the four fixed alkalis are naturally divided into two kinds of families, the one very eager for the water of cryftallization, and abforbing it from the air, in order to affume the cryftalline form; the other more foluble, and quickly liquefying in the water yielded to it by the atmosphere.

9. There is no known action between hydrogen gas, nor any attraction between hydrogen and strontian. Its action upon phosphorus is entirely similar to that of barites, which, because more energetic, was described at greater length. It combines with sulphur, like the latter in the dry, and in the humid way. It dissolves more than one third of its weight of that substance. The sulphuret of strontian has the greatest similarity to barites. Like the latter, it is either pure or hydrogenated. Strontian, likewise, combines with sulphurated hydrogen, and forms an hidro-sulphuret, the properties of which resemble those of the same combination with barites. When hydrogenated sulphuret, as well as the hidro-sulphuret of strontian, is decomposed by an acid, the sulphurated hydrogen gas, which is disengaged, burns with a fine purple flame, because it carries with it a small quantity of strontian in solution. I here rapidly point out these combinations, because I have described them, with much more precision, under the article of barites, which presents them still more evident though very analogous.

There is no reciprocal action between strontian, carbon, the diamond, and the metals.

10. The phenomena, presented by strontian with water, are so similar to those afforded by barites, that this resemblance, even for a length of time, induced the French chemists to believe that these two substances were exactly of the same nature, or that they were but one substance.

stance. A small quantity of water poured upon very caustic strontian, causes it to melt and bubble up with noise and heat; it hardens and presents, like barites, under similar circumstances, the rudiments of crystallization. If more water be added, it is diluted and dissolves. But there is here one of the most remarkable differences; a much greater quantity of water is necessary to dissolve it, than is required by barites. M. Klaproth found that it required more than two hundred parts of water at ten degrees of temperature to hold it in solution.

Hot water takes up much more of it than cold, and a boiling solution of strontian deposits the greatest part of its earth in crystals, by cooling. Its crystals differ in their form from those of barites which announces a difference in its nature. They frequently afford a kind of plates, or rhomboidal tables, less disposed to form prisms than those of barites. They sometimes, however, assume the figure of flat satin-like needles, or compressed prisms. This white crystallized strontian effloresces in the air; it is of an acrid taste, and almost caustic.

11. The solution of strontian in water is acrid, alkaline, and changes blue vegetable colours to green: it becomes covered with a pellicle when exposed to the air, like that of barites, in proportion as it absorbs the carbonic acid of the atmosphere; it is not venomous to animals, like the latter. When distilled it leaves the strontian pure, but flaked, that
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is to say, saturated with water, solid or dry, or retaining its water of crystallization, with which it has so much attraction.

12. No exact information has yet been obtained relative to the combinations of strontian with the metallic oxides; but its analogies with barites sufficiently announce that it is susceptible of adhering to them, like the latter, and that in these combinations it will afford some interesting phenomena.

13. Strontian readily combines with all the acids. It is in the properties of the salts which it forms with them, that the principal difference consists between this earth and barites, with which it is, besides, so nearly connected by many characters. Various other properties of the salts with base of strontian, appear to confound it with barites: but a difference which is alone sufficient to distinguish them with certainty is, that strontian, in general, has less attraction for the acids than the three first mentioned fixed alkalis have, and consequently that it can be separated from them by pot-ash and soda, while barites, which is stronger than the two latter, also completely and speedily precipitates strontian from all its saline combinations. I have already several times observed, and it will be useful here to recur to my observation, that it is more especially in the difference of the chemical attractions, that the real diversity which exists between the productions of nature ought to be

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be made to consist; and, in this respect, strontian widely differs from barites.

14. Although the attractions and effects of strontian upon the earths have been but slightly examined, the experiments of Citizen Vauquelin are sufficient to prove that, when treated by heat with flint and alumine, strontian acts upon them in the manner of fixed alkalis, as barites has been seen to act, according to the result of the same experiments. Three parts of strontian, and one part of flint, strongly heated in a silver crucible, for the course of an hour, afford a grey, sonorous, vitrified mass, perforated in several points, without any sensible taste, no longer becoming hot in water, like strontian, but little soluble in this liquid, carrying with it, however, some flint, which the muriatic acid dissolves, and deposits in jelly by evaporation.

Five parts of strontian, and one part of alumine, recently precipitated, and still humid, when boiled with water, afforded a solution of a small quantity of strontian and alumine, as well as another portion of this alkali and earth which formed an insipid combination, insoluble in water; and soluble without effervescence in the acids.

We may here easily perceive an action analogous to that of pot-ash and soda on flint and alumine, but it is more feeble, and indicates that these siliceous and aluminous combinations with barites and strontian may be found among the stones, and employed with advantage in

glafs-making, potteries, in the manufacture of glafs, pottery, enamels, &c.

There is no known combination between strontian, glucine, zircon, magnesia, lime, barites, pot-ash, and soda.

15. On comparing the properties of strontian with those of barites, we find that, notwithstanding the general resemblance of these properties, it differs, however, by being less harsh, less heavy, phosphorescent, colouring flame of a purple, infusibility, a solubility ten times less, a form really different, and particularly by the saline compounds, and the much weaker order of its attractions. Two essential differences may here be observed, the one that of changing, by its saline compounds, and particularly by its muriate, the flame of alcohol to a fine red purple, while barites only turns it yellow; the other, a discovery or confirmation by Pelletier, is that of its not being poisonous like the latter.

16. The intimate nature or composition of strontian is no better known than that of all the other earthy and alkaline bases. It ought no longer to be supposed, at least without admitting an hypothesis destitute of proof, that it is formed of a metallic oxide, any more than could be said of barites. It is even reversing, by an improbable hypothesis, all the received ideas, to regard it as a burned body, as an oxide. Strontian has not yet been employed for any purpose; it has been too seldom met

met with in fossils; though there is reason to believe, that it is very abundant in nature; besides which its properties, and those of its combinations, have not yet been sufficiently examined to apply it to any useful purpose; but it is to be hoped that it may hereafter become of great utility in the arts.

ARTICLE XIII.

Of Ammonia.

1. AMMONIA, the fifth and weakest kind of alkali, was formerly denominated *volatile alkali*, *volatile spirit of sal ammoniac*, *fluor volatile alkali*, and *caustic volatile alkali*. The word *ammonia*, adopted since 1787, is derived from *sal ammoniac*, from which this species of alkali is commonly extracted, and the name of which itself is derived from Ammonia, a country of Lybia, where this salt has been prepared, from time immemorial, from sand, impregnated with camels urine and excrement, which will be spoken of in the following section. The word *ammoniac* has received in the French methodical nomenclature the termination of *aque*, in order to render it similar to those of barites, pot-ash, &c. in the genus, as that alkali is by its properties.

2. Ammonia appears to have been absolutely unknown to the ancients. It was in the fifteenth century, in the works of Basil Valentine that the first idea was published of the separation of this alkali, and of some of its properties. At the close of the seventeenth century it was not, however, distinguished from the other falsifiable bases, though the method of obtaining it from distilled animal matters was known, and it had even then been designed by the names of *volatile spirit*, *volatile salt* of blood, of the viper, of hartshorn, &c. The analysis of sal ammoniac, which was not made with attention till the beginning of the eighteenth century, was the epoch when it was discovered to be very different from the fixed alkalis, and when the name of volatile alkali began to receive an exact appreciation. From that period till the discoveries of Black, on the two states of caustic and mild alkalis, on their being rendered mild by fixed air, or carbonic acid, a continual error prevailed relative to volatile alkali; it was supposed to be pure only when in the crystalline and solid form; a salt was then mistaken for this substance; in its pure, caustic, and fluid state, it was supposed to be changed, and, as it were, spoiled by lime, or the different substances which had been used to extract it from sal ammoniac, though this was its real, pure, and natural state. This error was, at length, destroyed by the discovery of the carbonic acid. Dr. Priestley soon afterwards examined

amined it under the form of gas, and decomposed it by electricity, without however knowing of what it consisted. Scheele and Bergmann, by their exertions, ascertained its composition between the years 1775 and 1788. Citizen Berthollet determined it with accuracy, by explaining its formation and decomposition in 1785. It is since this last-mentioned epoch, that the history of this species of alkali has been rendered complete, and as easy to be explained as conceived, since none of its properties remain obscure.

3. Ammonia exists in nature, but in far less quantity, less generally, and is, in some degree, less permanent than the other four alkalis, because it appears to be both more easily formed, and more readily decomposed. It is said to be found in the vicinity of volcanos, combined with the sulphureous and sulphuric acids; it is not met with among the fossil salts it is incessantly disengaged from some vegetable substances, and particularly from animal matters during their putrefaction on the surface of the globe. That which is procured for the use of the arts and chemical laboratories, is almost always the produce of one entire fabrication. It is made in the direct way, by decomposing animal substances by heat in a distilling apparatus; and this is the same as that which takes place in the manufacture of sal ammoniac, or the muriate of ammonia, in whatever manner
or

ner, or by whatever process it may be prepared.

4. As this salt is prepared in the large way in many manufactories, and as it is a sort of reservoir for chemists, wherein the ammonia, being contained in abundance, and completely formed, may be extracted pure by easy and speedy means, it is commonly from this salt that it is separated, by means of lime, which has more attraction for the muriatic acid than ammonia has, and which disengages the latter easily and rapidly, in proportion as the lime combines with the acid. As the process by which this useful product is obtained, belongs entirely to the history of the muriate of ammonia, and will necessarily be described in the article devoted to the muriatic salts, I need here only indicate the result which it affords. In chemical laboratories, as well as in several manufactories, ammonia may also be fabricated, and even obtained in great quantities by the distillation of animal substances, particularly from urine, putrid flesh, cuttings of wool, from bones, treated either in retorts, or in iron or earthen tubes, with a very simple apparatus, to conduct the ammoniacal vapour into water where it is condensed. This species of liquid ammonia must then be purified, as in this first preparation it is foul, and impregnated with oil; it must therefore be rectified by a gentle heat, after having mixed with it a small quantity of lime.

5. Ammonia

5. Ammonia may be easily obtained in gas, either by the experiments already pointed out, or by a process made use of for the purpose, of heating muriate of ammonia mixed with quick-lime, or with liquid ammonia, extracted by the method already mentioned, in a small retort, or matrafs of glass, terminated by a long neck or tube, placed in a receiver full of mercury, in a tub filled with the same metal. As in the gaseous state the ammonia is more pure than when in the liquid form, the properties of ammoniacal gas shall first be described, and afterwards liquid ammonia, when the examination of the properties of this gaseous body shall have led to its combination with water, and the formation of ammonia from it in its common state, in which state it is most easily preserved, and most frequently employed, on account of the smallness of its bulk.

6. Ammoniacal gas, enclosed in a receiver, perfectly resembles air, by its transparence and invisibility, as well as by its compressibility, though it differs from that fluid in all its other properties. It is lighter than common air; Kirwan found that a cubic inch of this gas weighed only 0,27 parts of a grain, while air weighs only 0,46. Its weight, therefore, is not quite the half of that of air. It has a quick, pungent, and acrid smell, which strongly irritates the eyes and nostrils, restores the relaxed motion of animals, when employed as a stimulant and cordial to recover them from a
state

state of fainting or weakness. It is, however, not respirable, and itself suffocates animals. The smell of this gas is said to be urinous, because, in fact, corrupted urine exhales a great quantity of ammoniacal gas, but this smell, in the latter instance, is mixed with putrid effluvia.

Ammoniacal gas has an acrid and caustic taste, much weaker, however, than that of the fixed alkalis, and it does not dissolve animal substances, as pot-ash and soda do. It quickly changes the colour of violets and radishes, to green, and turns the yellow colour of turmeric to a brown red. Though it extinguishes lighted candles, it considerably increases their flame, and even deflagrates when very hot.

7. Light does not affect ammoniacal gas. Caloric dilates it in a proportion unknown. Porous bodies, as charcoal, sponges, and cork, absorb and condense it. Whatever may be the mass and intensity of the caloric with which it is impregnated, it does not undergo any change in its nature; on passing it through a tube of ignited porcelain, it is not decomposed. Electric sparks, on the contrary decompose it, according to the experiments of Dr. Priestley and Citizen Van Marum; it there separates into two gases, viz. azote gas and hydrogen gas. Thus the electric fluid insulates and dissolves those two principles, and melts each of them into an elastic fluid; and by this process alone its nature, composition,

sition, and even the proportion of its two component parts are known.

8. Ammoniacal gas has no action in the cold by simple contact, or simple mixture upon oxygen gas, which decomposes it at a high temperature. On passing these two gases, when mixed together into a tube of red-hot porcelain, there is a decomposition of ammonia, an inflammation and detonation of its hydrogen, which passes to the state of water, and even a formation of nitric acid, if the proportion of oxygen gas be considerable; but if this latter be not in a proportion sufficient to saturate the hydrogen of the ammonia, there is a residuum of azote gas after the condensation of the water which is formed. On making this experiment with attention, it is discovered that the azote is much more abundant than the hydrogen in the ammoniacal compound.

9. There is no combination between azote gas and ammoniacal gas. The common air formed from the two gases, oxygen and azote, does not act at all in the cold, and by simple mixture with ammoniacal gas. The latter being lighter is displaced by it in the vessels, the aperture of which is turned up, this gas dissolves in the atmosphere, and combines with its carbonic acid. At a high temperature, in a tube of red-hot porcelain, ammoniacal gas, mixed with a sufficient quantity of atmospheric air, is burned; some water is formed, and the elastic fluid residuum contains
both

both atmospheric azote gas, and that which proceeds from the decomposition of ammonia.

10. No effect is known between ammoniacal gas and hydrogen gas, at any temperature, doubtless because in this volatile alkali, there is a complete saturation between the azote and the hydrogen which forms it, and because it cannot take a greater quantity of this principle than it contains.

11. In cold no action, nor combination is observed between ammoniacal gas and carbon; this gas is only perceived to be condensed and absorbed by charcoal. But when ammoniacal gas is passed into a tube of porcelain, containing red-hot charcoal, an acid of ternary radical is formed, consisting of azote, hydrogen, and carbon, combined, without doubt, with a small proportion of oxygen, which is found in the water, accompanying the gas or the charcoal, or in the air which remains in the cavity of the tube. This acid will be examined in the history of the animal matters, which abundantly contain the four principles necessary to its composition. I shall speak of it under the name of the prussic acid, in the examination of those substances, from which it is prepared, by various chemical processes: it is sufficient to observe here, that it is formed by the re-action of ammonia and carbon exposed to a red heat.

12. Phosphorus does not dissolve in ammoniacal gas, except by heat, and when the temperature

ture is very high, as in a tube of red-hot porcelain: some phosphorated hydrogen is then formed, and there remains azote gas, saturated with phosphorus. The decomposition of ammonia takes place here, by a double action of the phosphorus, which attracts on one hand hydrogen, and on the other azote, by being dissolved, in each of these insulated gaseous bodies.

13. Ammoniacal gas does not act upon sulphur in cold; by heat it dissolves it when the sulphur is in vapour, and an ammoniacal sulphuret is formed, which speedily condenses in water, easily decomposes it, and constitutes a smoking hydrogenated sulphur, which will be spoken of hereafter in the history of liquid ammonia. Ammoniacal gas also combines, though with difficulty, with sulphurated hydrogen gas, and forms an ammoniacal hydrosulphuret, which will be described hereafter, as well as the preceding, because it is prepared more easily with liquid ammonia.

14. No action is known between ammoniacal gas, the diamond, and the metals: the water which the gas often holds in solution, is easily decomposed by some metallic substances, when they are plunged in ammoniacal gas. Their surface is covered with a coating of oxide, which absorbs the ammonia, and a small quantity of hydrogen gas is found in the apparatus.

15. Ammoniacal gas readily and easily combines with water in all its states. When ice is brought

brought into contact with this gas, it immediately absorbs and condenses it; it melts, and becomes entirely liquid; and some cold is always produced, whatever may be the proportion of the two bodies that are mixed together. This constant cooling originates in consequence of the water, on fixing the ammoniacal gas, becoming more rare and light than it naturally is; and because on acquiring this liquid, its capacity for caloric increases, or requires the absorption of a greater quantity to preserve this state of rarefaction. Liquid water, on the contrary, in proportion as it condenses the ammoniacal gas, becomes hot, on account of the loss of caloric, caused by the gas on liquefying, and which exceeds the quantity required by the water, in order to take the degree of rarefaction which it acquires in this combination. When the water, which absorbs the ammoniacal gas, and which is now presented to the contact of this gas, in all the operations in which liquid ammonia is wished for, has attained 50 degrees of temperature of the centigrade thermometer, it retains no more of it; that which is produced, passes in great bubbles through the liquor, without any diminution in bulk as before, and breaks at the surface, in a white smoke, in consequence of the water which they dissolve, at their elevated temperature, a part of which they deposit on arriving at the air of the vessel. As the gas undergoes no further condensation, the liquor gradually cools,

cools. The condensation then again commences, but the less abundant caloric, which is disengaged by this second portion of fixed gas, being carried off by the vessels and the external air, an equilibrium of temperature is speedily established between this liquor, the vessels, and the surrounding air; and at this point the saturation of the water is complete. This liquid thus takes up, and liquefies nearly half its weight of ammoniacal gas; the water increases more than half its bulk, and loses rather more than the tenth of its specific gravity. In this state it weighs 897, the water weighing, under the same bulk, 1000. It is this water, thus saturated with ammoniacal gas, that is most frequently employed in experiments, on account of the small bulk which it occupies in comparison with ammoniacal gas, and of the facility with which it may be preserved. Its properties will be examined hereafter, because it is important that this species of alkali should be well known, in that state in which it is most common and convenient. It will be seen in the history of the muriate of ammonia, that on decomposing it by lime, in order to obtain ammoniacal alkali, this property of ammoniacal gas is employed with great advantage, to condense in cold water, in order that nothing may be lost, and to obtain a product equally pure and abundant.

16. Ammoniacal gas does not much combine with the metallic oxides; some of them, however.

however, absorb it and combine with it, almost in the saline state. Others, which are those that least adhere to oxygen, when brought in contact with this gas, partly decompose it, giving out their oxygen to its hydrogen, and are disoxidized. Almost all the oxides produce this effect with ammoniacal gas, when they are passed through this gas at the red temperature in tubes of porcelain; there are even some which, from the great quantity of oxygen they afford in this case, entirely decompose the ammoniacal gas, and convert it into water and nitrous acid. We shall return to this subject, when speaking of liquid ammonia, because under this form it is most frequently and most easily treated by the metallic oxides.

17. Ammoniacal gas is fixed, liquefied, and sometimes even rendered solid by all the acids, with which it easily combines, though its attraction for them is weaker than that of strontian, soda, pot-ash, barites, lime, nearly equal to that of magnesia; and only stronger than those of alumine, glucine, and zircon. By uniting with them this gas immediately loses its elastic form, gives out a large portion of caloric, and constitutes the salts called ammoniacal, of which the properties will be described in the following section. But as the union of the alkali, under the gaseous form, presents with the acids, certain phenomena, which are very interesting to be known, we shall describe

scribe them in this place, in order to render the history of ammonia more complete. The properties of the salts, which will constitute the subject of the following section, ought not besides, to be explained but in their complete combination, whereas we must here treat of the effects which take place at the very moment of combination.

18. When ammoniacal gas is passed into carbonic acid gas, the moment the first touches the latter, and tends to rise through it on account of its specific lightness, a light vapour, scarcely perceptible, is formed, the two gases become condensed, caloric which leaves them is disengaged, and a crystallization of a salt, or carbonate of ammonia, in silky fibres, or fine powder, takes place against the internal surface of the vessel. This operation, like all those in which an acid gas is combined with ammoniacal gas, must be made over mercury, and not water, which would condense both before they could unite, and would prevent the phenomena of their mutual union from being seen.

19. Ammoniacal gas is rapidly condensed and absorbed by the liquid phosphoric acid, by the phosphoreous acid, and by the sulphuric acid, and in the same state, much caloric is disengaged; phosphate, or sulphate of ammonia are formed, which salts will be described more particularly in the following section.

20. When ammoniacal gas is introduced into phosphoreous acid gas, a great penetration immediately

immediately takes place between the two fluids, with an abundant disengagement of caloric. A white fume fills the vessel at the instant of the mixture. Concrete phosphite of ammonia is deposited on the sides of the vessels, in flocks of a reddish yellow, frequently varied, and as it were spotted in their colour, but which become white, and capable of affording transparent crystals when dissolved in water.

21. Ammoniacal gas is condensed very speedily in nitric acid. On the slightest contact of this gas with the vapour which rises from concentrated nitric acid, white fumes of nitrate of ammonia appear already condensed; this experiment is so marked, that the nitric acid, slightly fuming, or not at all so, is often used by moistening a glass rod with it, in order to judge whether any fluid in which the presence of ammonia is suspected, in too small quantities to be perceptible or evident, do really contain this volatile alkali: and this is considered as decided when the fluid becomes covered with a white vapour on the approach of nitric acid. It is almost needless to remark, that much caloric is disengaged at the time of combination between ammonia and nitric acid. At an elevated temperature, much below that required to ignite a porcelain tube, ammoniacal and nitric acid gas, mutually decompose each other, and take fire. Water is formed, and the radical azote, which was acidifiable in the one body, and alkalifiant in the other, is disengaged. We shall return
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to this phenomenon when we treat of nitrate of ammonia.

22. The acid denominated nitrous in our laboratories, that is to say, the nitric acid containing different proportions of oxidized azote, or nitrous gas, also absorbs the ammoniac gas; but the caloric which is separated volatilizes the nitrous gas, so that the combination affords only nitrate, and not the nitrite of ammonia, as might be expected. It is the same with the true nitrous acid, the ruddy nitrous vapour, or nitric acid, saturated with nitrous gas, and holding, as has been elsewhere observed, a tenth part less than its own weight. When ammoniac gas is mixed with this vapour, a dense white vapour is reproduced with the disengagement of much caloric, and a complete condensation takes place; the red colour disappears; nitrate of ammonia is formed, which deposited in crystalline powder and nitrous gas, remains in the apparatus, which may be again rendered ruddy and changed into new nitrous vapour by the addition of oxygen gas. Ammoniac gas, therefore, decomposes the nitrous vapour by absorbing the nitric acid, or nearly $\frac{5}{9}$, and disengaging the nitrous gas which is very nearly $\frac{4}{9}$ parts of the whole.

23. Ammoniac gas is difficultly absorbed by the metallic acids; water is necessary to favour their union; we shall, therefore, speak again of these combinations when we treat of liquid ammonia which easily forms them.

24. The union of ammoniac gas with the muriatic acid gas is one of the most energetic and most remarkable phenomena which these bodies presents. When the former is introduced into an inverted vessel filled with water, it penetrates it with a degree of speed and activity difficult to be described; a sudden condensation takes place with considerable heat; and a white vapour, or fume, so thick and so abundant that the vessel becomes perfectly opaque. The muriate of ammonia is formed, and deposited on the sides in small silky needle-formed crystals, or in light pulverulent flakes, according to the quantity of water respectively contained in the two gases. This experiment is one of the most striking examples of two gaseous bodies instantly converted into a solid body, and the rapid precipitation of two solidifiable bases, each abandoning, on its part, the caloric which held them in solution, because they have more attraction for each other than either had for the gaseous solvent. On account of this rapid and powerful effect of mutual condensation between ammoniacal gas and muriatic acid gas, this last dissolved in water, or the liquid muriatic acid, is used to ascertain the smallest portion of ammonia which is then rendered sensible by white vapour formed in its vicinity. It is often preferred for this experiment to the nitric acid.

25. There is no combination between ammoniac gas and oxygenated muriatic acid gas, but an instantaneous decomposition of both. I have

have discovered that, when the first of these gases is passed into the second, inflammation follows, with the disengagement of a white light during the union of the oxygen with the hydrogen of the ammonia; the water which is formed at the same time, presents a very dense white vapour. It dissolves the muriatic acid and azote gas remains. There is only part of the ammoniac gas decomposed because part of the oxygenated muriatic acid, which is first deprived of its oxygen, combines with a portion of the gas, and changes it into muriate upon which the oxygenated muriatic acid that remains has no longer any action. In this experiment we have one of the proofs of the nature of ammonia, and its composition from azote and hydrogen. Though this experiment cannot serve to determine the proportions of its principles because part of the ammoniacal gas escapes decomposition, the small quantity of water obtained, and the volume of azote gas which remains compared with the primitive dose of the two gases made use of, shows that azote is much more abundant in ammonia than hydrogen.

26. Ammoniacal gas unites rapidly with the fluoric acid gas; in its condensation a white dense vapour, disengagement of caloric, precipitation of flax, and formation of solid and crystalline ammoniacal fluuate takes place. The acid of borax does not absorb ammoniacal gas.

27. There is neither action nor union between ammoniacal gas and the earthy substances. It is already known that lime has the property of disengaging ammonia in gas from its combination, as do likewise barites, pot-ash, soda, and strontian. Frequently also the very pure alkaline matters in a caustic and concentrated state, by acting upon complicated compounds, which contain among their principles much azote and hydrogen, such as the animal substances, detach these two bodies from the composition in the proportion and state suitable to the formation of ammonia, which is then disengaged in gas. Thus it is when lime, barites, pot-ash, soda, and strontian, are introduced into liquids, or solids, which do not contain ammonia ready formed, that a quantity of this volatile alkali is formed at the very moment of their contact, and particularly by trituration with these substances. We shall, again, consider this fact, in the section upon animal matters.

28. It is not enough that we should examine the characters and properties of ammoniacal gas, because this species of alkali is not usually preserved and applied in experiments under this form; we must also study it under the liquid form which it most frequently possesses, and which is given to it in order to use it with more facility or advantage in the arts, or medicine, or even chemistry. I have shown how the liquid ammonia is procured; I have described the phenomena presented by ammoniac gas during

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ing its fixation in water. We will now proceed to describe the habitudes of liquid ammonia, its combinations, or decompositions, and the differences it presents when compared with ammoniacal gas.

29. We must observe, in the first place, that, as the volatile alkali is much more frequently obtained in the liquid than in the gaseous form, and as it is more convenient for every kind of use, this fluid ought particularly to be denominated ammonia, and the expression ammoniacal gas reserved to denote the state of elastic fluidity. This ammonia, in the liquid state, has been named fluor volatile alkali, caustic volatile alkali, alkaline spirit, volatile spirit of sal ammoniac; it is prepared and preserved for medical and manufacturing purposes, by decomposing the muriate of ammonia by lime, and receiving it in cold water, by means of conducting-tubes, the ammoniacal gas which is disengaged, and of which the greater part formerly was lost through the apertures necessary to be made in the vessels to avoid bursting, before the discovery of Woulfe. This liquid is, therefore, a combination of ammonia and water.

30. Ammonia is lighter than water, equally transparent, of a lively penetrating smell, not respirable, unless rapidly; and, by intervals, of an acrid and almost caustic taste, though it does not burn; it dissolves animal matters like the concentrated lees of pot-ash and soda, strongly converts violets and many other vegetable colours to green,

green, changes the yellow tincture of curcuma to a brown, is, in no respect, alterable by light which it refracts merely in a ratio superior to that of its density, because it is composed of two combustible bodies. When heated with caloric, it is speedily fused and separated in the form of bubbles, the ammonia which is disengaged in gas with effervescence, may be collected over mercury. It boils much more speedily than water, and, at forty-five degrees, is in full ebullition on account of this disengagement of gas; it is difficult to separate the last portions which adhere with considerable strength to the water. Ammonia cannot be obtained in a form nearly solid, or at the consistence of an opaque jelly, but at the temperature of thirty-two degrees under 0. At the cold which congeals mercury, it is fixed and becomes opaque.

The diminution of pressure, such, for example, as takes place on the summit of mountains, where the weight of the atmosphere diminishes with its height, produces the same effect upon ammonia as caloric, and disengages it from the water. On the contrary, cooling, as well as the increase of pressure, assists the liquid combination of ammonia with water, fixes it more effectually, and even increases the aqueous solution of ammonia. Advantage is taken of these two united circumstances, namely, the pressure of an elevated column of water, and cooling by means of ice mixed with sea-salt, with which the bottles serve as receivers, are placed in order to
compose

compose a very strong and very concentrated ammonia; the ammonia prepared by these processes, therefore, becomes much more odorant, and almost spontaneously effervescent, when carried from a cool place into a hotter, from a low situation to another more elevated in the atmosphere, as is observable in the transition from winter to summer; this last circumstance is frequently sufficient to break the containing vessels.

31. Ammonia is not affected by the contact of oxygen gas, or azote gas. When exposed to the air in an open vessel, part of the ammonia is disengaged in gas, expands, and is dissolved in the atmosphere; the upper strata of water which are then deprived of their alkali, fall in visible streams through the most saturated and lightest portion of the water which then possesses the lower place, and gradually mix with it to re-establish the equilibrium of solution when the surrounding air is saturated with ammoniacal gas. At the same time, the carbonic acid of the atmosphere is precipitated into the liquor, unites with the ammonia, and communicates to it the properties of carbonate of ammonia particularly the power of double attraction which this salt possesses, and causes it to produce, as we shall see in the following section, effects of decomposition, which the chemists have formerly attributed to the volatile alkali, at that time mistaken with regard to its state of purity.

32. Ammonia

32. Ammonia exercises no action upon hydrogen gas, carbon, and phosphorus; there is neither absorption nor solution, nor any change whatever in these bodies placed in contact with each other. If they be heated together, the ammonia being reduced into gas, acts, as has been before shown, when we considered it under this state.

33. Neither is there any sensible action between ammonia and sulphur. By distilling a mixture of muriate of ammonia, lime, and sulphur, a compound is prepared which is formed by the sulphur and the ammonia in vapour, which re-acts upon the water disengaged at the same time from the mixture, and partly dissolved in it. It is an hydrogenated sulphuret of ammonia, of a deep yellow colour, which emits a fetid vapour, visible in the air on account of the ammonia which it contains in excess, and which has long been denominated the fuming liquor of Boyle, because it was discovered by that philosopher. This sulphuret is totally decomposable by fire, by acids, and by sulphurated hydrogenous gas.

34. Ammonia absorbs hydrogen gas so promptly, that it is only necessary to pass this gas into it by means of a tube, or to agitate it in a vessel with liquid ammonia, in order to saturate it; this saturation is attended with a disengagement of caloric, a yellow colour, and the formation of vapour. The hydro-sulphuret of ammonia which is thus prepared is crystallizable; it

it has not the fetid smell of the hydrogenated sulphuret. It is decomposable by caloric, by the contact of oxygen gas, acids, and metallic oxides. It has, for some time, been considered as a very valuable medicine, in cases where it is thought that the humours are too oxygenated, or the solids too active by the super-abundance of oxygen. It speedily produces a great weakness in the organs of animals.

35. No action is observed between ammonia and the diamond. This volatile alkali, in the liquid form, attacks the metals more strongly than ammoniacal gas, on account of the water it contains, and its decomposition by the metallic substances which it facilitates. Ammonia consequently acts so sensibly upon the metals which are most greedy of oxygen, that it produces an effervescence, and causes a disengagement of hydrogen gas; it afterwards unites to part of the metallic oxides thus formed.

36. Water unites in all proportions with liquid ammonia, with a disengagement of a portion of caloric, by which means it loses part of its force, its alkaline harshness, and its specific lightness.

37. A much more evident action is observed between the metallic oxides and ammonia, than between these bodies and ammoniacal gas. The water favours, and also permits us to estimate, and understand with more facility, the phenomena which pass between these substances. In general, the metallic oxides are affected in
four

four different manners with liquid ammonia ; some metals dissolve in it without other alteration on the part of either principle, and form with it saline compounds, in which they act the part of acids ; such are the oxides of zinc, tin, silver, &c. The other oxides are partly decomposed, or suffer part of their oxygen to be seized by the hydrogen of the ammonia with which it forms water, so that the azote, which is the other principle of ammonia, is disengaged in gas with effervescence, while the oxide approaches the metallic state. Citizen Berthollet, who has well described this action, availed himself of it to ascertain the proportion of the principles of ammonia. The green oxide of copper is particularly in this situation ; it passes, by means of heat, to the state of brown oxide, by decomposing the liquid ammonia, of which the azote is disengaged in the form of an elastic fluid with effervescence. There are some oxides which are entirely decomposable by ammonia, such as those of gold and silver ; during this total decomposition, which is effected either by heat, or by mere contact and friction, a violent detonation is produced, arising from the sudden expansion of the hydrogen, and the oxygen at their union, and the azote at its disengagement : we shall speak of it in the history of silver and gold. Lastly, certain oxides, by being decomposed in part by ammonia, which they, at the same time, completely decompose, form water with its hydrogen, and nitric acid with

with its azote, as is observed with the oxides of manganese, of mercury, and of lead; and so likewise with bodies very greedy of oxygen, which, at the same time, decompose water and the nitric acid, the azote and hydrogen, of those two compounds are converted into ammonia; whereas, on the other hand, when ammonia is treated with bodies which contain, and yield much oxygen, its principles may be separated, and united singly and solitarily with oxygen, which causes them to appear under the form of nitric acid and water. These mutual transmutations, the happy results of modern discovery, by developing the bases of the pneumatic doctrine, and explaining phenomena formerly unknown, or unintelligible, give great force to this doctrine, and demonstrate its proofs.

38. All the acids unite with ammonia by heat, whence they disengage caloric, and form salts, which will be examined in the following section. The phenomena of its union with acids are not so remarkable as those which accompany its combination in the state of gas, because its liquid form does not admit of all the changes which take place, when it passes from the gaseous state to the solid and crystalline consistence.

39. Ammonia is decomposed by the oxygenated muriatic acid, but with phenomena different from those that take place between those two gaseous bodies; there is no inflammation between them as between the gases. When liquid

liquid ammonia and liquid oxygenated muriatic acid are brought near each other, a white vapour is formed by the appulse of their tubes. When four-fifths of its volume of oxygenated muriatic acid are poured into a tube, closed at one of its extremities, and one-fifth of liquid ammonia poured thereon, and the tube is reversed, by closing its open extremity with the finger, so that the closed part shall be placed uppermost, and the open part plunged in water, the ammonia, being lighter than the acid, passes through it; a lively effervescence is excited, and azote gas is collected from above the fluid; this last contains a small quantity of muriate of ammonia. Thus we see, that under the liquid form, as well as in that of gas, these two bodies mutually decompose each other; the oxygen of the oxygenated muriatic acid seizes the hydrogen of the ammonia with which it forms water, while the other principle of this alkali, being set at liberty, assumes the state of gas. The muriatic acid, being set free, unites accordingly with a portion of ammonia. We may avail ourselves of this decomposition, to obtain azote gas, by passing the oxygenated muriatic acid gas through liquid ammonia, in an apparatus proper to collect the gas. We see that there is no permanent combination between ammonia, and the oxygenated muriatic acid; there exists no oxygenated muriate of ammonia. Citizen Vau-Mons has, nevertheless announced, that this combination may take place without decomposition,

composition, at temperatures below that of melting ice. Citizen Vauquelin and myself made such a mixture, by taking ammonia cold and congealed by thirty-two degrees below 0, and the oxygenated muriatic acid also cold and congealed; notwithstanding this low temperature, a considerable movement was excited by a disengagement of very dense white vapour, and decomposition of the two bodies.

This beautiful property of the reciprocal decomposition of ammonia, and the oxygenated muriatic acid, the discovery of which we owe to Citizen Berthollet, who has been conducted by it to the accurate knowledge of the nature of the volatile alkali, affords a means of preventing the bad and dangerous effects of the oxygenated muriatic acid gas upon our organs. For this purpose, it will be sufficient if we put cotton, externally impregnated with ammoniac, between our lips, and in our nostrils: this forms a sort of barrier between the active gas and the throat and nose; so that being decomposed before it reaches them, it produces none of the effects that render it dangerous, or, at least, very troublesome.

40. Liquid ammonia exerts no solvent action upon flint, zircon, and glucine, in however large quantities we may employ it, and however high we may raise the temperature. It dissolves alumine in small proportion, when this earth is in a state of extreme division; it enters with it into ternary combinations with the acids. It
exerts

exerts no action at all upon pure magnesia and lime : these earths, being more powerful than itself expel it from its combinations, especially with the aid of heat : it, however, in part disengages magnesia from its combinations ; it, nevertheless, associates itself with it in ternary saline compounds, or in trifles, of which we shall speak in the following section ; it therefore, almost equals magnesia, with respect to its attractions with the acids. It does not unite either with barites, or pot-ash, or soda, or strontian, which are much stronger, and much more powerfully attracted than it is, in their salified combinations. Water, saturated with ammoniacal gas, does not absorb any more of it, unless when refrigerated to a great degree. This produces no alteration in the properties of the ammonia, but only gives greater energy to its alkaline effects

41. We see from the preceding details, the extent of which is authorised by the importance of the substance to which they relate, that ammonia is a species of alkali which has the greatest relation with most of the phenomena of the science ; that it is the only alkali, the composition of which is exactly known ; that it is susceptible of decomposition by a great number of substances, and especially those that are most oxygenated ; that it is composed of about four parts of azote and one of hidrogen, or to give the proportion more accurately, that the azote is to the hidrogen as 121 to 29 ; that
whenever

whenever these bodies meet at the moment of their infulation in fuitable proportions, ammonia is formed, as takes place in the treatment of animal substances by heat, by putrefaction, by the caustic fixed alkalis, in the decomposition of the nitric acid, accompanying that of water; that, on the contrary, whenever ammonia is in contact with bodies furcharged with oxygen, and which readily abandon it, this principle, by seizing its hidrogen, and converting it into water, separates from it the azote, almost always in the form of gas; and that in general, though it frequently combines in its entire state, it incessantly tends to decomposition in which circumstance it differs greatly from the four preceding alkalis.

42. The knowledge of the nature and properties of ammonia has diffused a great light over the general theory of chemistry, and contributed much to the progress of the science. The real effects of this species of alkali have been ascertained in a great number of operations; its particular attractions, verified with great exactness, have illustrated a multitude of facts relative to the decomposition of salts. The history of the double attractions, and of the disposing attractions, has been thus greatly advanced. The property of yielding ammonia, in a great number of analytical processes, has been determined and appreciated in the animal substances, which, considered with relation to this property, had so long and so fruitlessly occupied

pied the attention of chemists. The formation of this alkali, and its decomposition in a numerous train of chemical operations, has become a phenomenon easily to be accounted for, whilst formerly they presented a problem of great difficulty. The inflammations and detonations, occasioned by ammonia under various circumstances, which had been neglected prior to the new discoveries, have now nothing that can embarrass chemists, who are no longer obliged, in order to explain them, to have recourse to the hypothetical and vague theories which have so long prevailed in the schools. The mutual relations of formation, and decomposition, between the nitric acid, water, and ammonia, relations which deserve to be considered as one of the finest acquisitions of the pneumatic doctrine, were seized, and clearly conceived the very moment they were discovered. The analogies of several vegetable substances with animal substances in the production of ammonia, no longer presented those difficulties and uncertainties which, during so great a length of time, embarrassed the science. Lastly, the composition of animal substances, the varied circumstances of their decomposition, or of the putrefaction which changes their nature, and which sometimes favours the production of the nitric acid in them, and sometimes develops in them the formation of ammonia, have been ascertained with a clearness and precision which would

would have been fought in vain in the ancient theoretical hypothesis.

43. These lights have been at once diffused over the most important uses of ammonia; over its medicinal properties, and its use in diseases. It has been seen that it is not a specific in asphyxia, as had been pretended, and that it does not restore animation by its property of absorbing acids, but by its stimulant quality, as it excites the vital actions in incipient asphyxias produced by other elastic fluids, as well as the acid gases. It has been found that it ought not to be used without caution, and especially inwardly, on account of its acrimony, as had been too often done in weakneses; and that, in order to avoid the mischief which might arise from this inconsiderate use of it, people ought to be advised not to wear bottles filled with liquid ammonia, but a kind of scent-box containing a sponge impregnated with ammoniacal gas.

Externally, we have learned to employ it as a solvent, discutient, a very powerful attenuant, and even to produce inflammation; it gives ease to parts that have been burned, nipped by the frost, stung by insects, &c. Internally, its use has been appropriated to a great number of cases, and especially to the spasmodic affections, but with less confidence, however, especially with respect to its specific powers in syphilis and cancer, than had at first been announced. An heroic remedy has been found in the ammoniacal hidro-sulphuret, as powerfully asthenic.

44. Amongst all the re-agents used in chemical laboratories, there is none which is of greater power, or which is more frequently employed, than ammonia. It is used in a multitude of operations, precipitations, decompositions, and analyses, in which it is employed with much greater success than was formerly the case, since its intimate nature and its properties have been known. We shall see many of its applications in the ensuing sections. In the arts, in workshops, and in manufactories, it has great influence upon the success of the processes which are there practised. Frequently even it is prepared, or manufactured in large quantities by distilling animal substances, in order to be afterwards applied to different uses, for artificially composing sal ammoniac, or the ammoniacal muriate. We shall take care to point out the principal uses to which it is applied in a great number of the articles that will compose the following sections.

ARTICLE XIV.

Concerning the natural Combinations of Earths with each other, or of Stones. General and chemical Notions of Lithology.

1. IT has been seen in all the preceding articles, that none of the earthy and alkaline matters, nor of the salifiable bases of which the history has been given, exists insulated or pure in nature, but that art must always employ processes, more or less complicated, to separate them, and to obtain them in a state of purity. The compounds from which they are extracted, constitute the species of fossils which are called stones, and which when reduced to particles, more or less fine, by the mechanical action of waters, form the natural earths or soils.

2. The stones are then considered by chemists, as compounds of earthy or alkaline matters, with each other, and sometimes with metallic oxides. These give to them the colour which distinguishes them; pot-ash also is sometimes found in them. It is easy to conceive that the various properties of stones, arise from the different proportions of their constituent parts; such as their form, their hardness, their weight, their fusibility, their refractory quality, &c.

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3. Though the history of these natural compounds belong more particularly to mineralogy, of which it constitutes, under the name of lithology, an important part, the numerous uses which are made, even in chemistry, of stony matters, the light which that science begins to throw on the nature of stones scarcely known, the well-founded hope that accurate analyses will soon give to that branch of natural history the degree of certainty which it has hitherto wanted, induce me to include in this system, which ought to describe all the productions of nature, as well as all the products of art, these combinations of earths with each other.

4. Without entering into a detail of all the properties which are observed in stones, or even of the numerous varieties which nature presents, it is sufficient for the object which I have in view to present in particular paragraphs, 1st. A general outline of the characters which have been distinguished in stones, and have been used to distinguish them; 2d. A notion of the lithological methods founded on such of their characters as fall under the senses; 3d. A notion of the systems which have been established on their nature or their intimate composition; 4th. The course or order which the most modern lithologists follow, by the use of both these methods; 5th. The general processes or method of analysis which chemists employ to discover the constituent principles of

of stones; 6th. Lastly, Tables of the analyses made of the principal species of stones at present known.

SECTION FIRST.

Concerning the distinctive Characters of Stones.

5. IT is almost superfluous to observe in this place, that the stones and the natural earths or soils, in which they are changed by the movement of waters, usually constituted the first division of minerals or fossils, which naturalists divide into four classes; namely, stones, salts, inflammable bodies, and metals: and this distinction, this division of minerals into four classes, is founded on their physical properties opposed in certain respects to each other; the stones are distinguished by their hardness, their insipidity, their insolubility, and their non-combustibility: they also constitute the great mass of the globe, whilst the three other classes of bodies are never found but in disseminated portions, in distinct masses, beds, or veins, which can only be considered as accessories of the same mass of the earth.

6. As, on comparing the whole of the stones to that of the other three classes of minerals or fossils, characters proper to distinguish them have been found; there has also been found, on comparing the different stones with each other, characters capable of distinguishing them, and establishing

establishing unequivocal distinctions among them. The properties on which these characters are founded, and which have been much better studied in modern times, than has been done in the series of ages which have elapsed since the time of Aristotle to the present, are distinguished into three genera; namely, the physical properties or characters, the geometrical properties or characters, and the chemical properties or characters. Let us sketch rapidly what each of these genera presents to our observation.

*Characters derived from the Physical Properties of
Stones.*

7. It is necessary to remark, first, that the number of properties on which are founded the specific and distinctive characters of stony substances must be considerable, and that we must deduce them from whatever differences these natural compounds may present to the senses; because natural beings are not perpetuated by a constant generation like vegetables and animals, and have neither size, internal form, nor their colour constantly identical,—because they are independent of each other, and without any necessary connection, like that of the generative succession of individuals which constitute similar species, and there can be no real species among minerals. The latitude being very great which can subsist between these beings, however

however similar they may at first appear, it is evident that it is necessary to have recourse to a very great number of properties, in order to distinguish them with success. It is for this reason, that considerations respecting the physical properties of stones, have been so multiplied.

8. There are eight physical properties which it is usual to observe with care in stony matters; A. the density or specific gravity; B. hardness and elasticity; C. transparency or opacity; D. double or simple refraction; E. electricity; F. magnetism; G. colour; H. lastly, taste and smell.

A. *Specific Gravity.*

9. BUFFON is the first who perceived the importance of this character in stones, and rendered it useful. Before him, philosophers spoke of it only as an object of curiosity, or as a property applicable only to the use which was made of it in the arts. The Aristotle of France has presented it also as an essential character which may serve to separate, or to approximate the species of stones. Since this ingenious notion, much more attention has been paid to this property. Easy methods of examining it with care are at present had, either by the hydrostatic balance, or the hydrostatic instrument of Nicholson, or the gravimeter of Citizen Guyton.

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10. It is now well known that two stones different in colour, transparency, external or apparent form, grain or fracture, will be of the same species, or approximate singularly in their nature if they have the same specific gravity; that those, on the contrary, which are apparently similar in other respects, are really of different species when they differ in this quality; that there are, nevertheless, certain limits in this approximation of weight proper to distinguish either the identity or the dissimilarity of stones, as there are between the whole mass, or rather the totality of stones, and of metallic substances; lastly, that the lightest stone is at the most to water as 12,492 is to 10,000, and that the heaviest is to water as 44,161 to 10,000.

B. *Hardness.*

11. THE coherence of the stony particles present so many varieties, or modes of existence, that there is, in this respect, a great difference between the different species of stones. Some have so strong an aggregation that the hardest and highest tempered steel does not attack them; others strongly resist instruments which attack them though with difficulty. All these last detach, by a brisk stroke from steel, particles of that metal which, being thus strongly heated, take fire in the air, and form those sparks of inflamed iron which are produced in striking fire;

fire; these stones are denominated scintillant. Many others are easily scratched or cut by steel; these are easily chiseled into shape; some of them are even almost soft, or extremely easy to be broken or pounded.

12. The property of assuming a polish, the nature and the difference of that polish, even depend on the greater or less approximation of the particles of stones or their hardness. A series of varieties, or many shades, in the polish of which stones are susceptible, may be distinguished, because this property is of great use in the arts, either for purposes of amusement or of utility. Thus we say, a bright polish, a hard polish, a greasy polish, a brilliant polish, a fine polish, a coarse polish, a common polish, a high polish, &c.

13. Though the file, the punch, and the steel, are the principal means which are used to estimate the hardness of stones, the mutual action of their species, or varieties, is also used with advantage, on each other. The solid angle of one stone is rubbed on the surface of the other, and thus by comparison a judgment is formed of their respective hardness. This method frequently serves to distinguish them with sufficient accuracy. The processes of the arts, the cutting, sawing, engraving, turning, shaping, and polishing stones by the different processes of the workshop also afford valuable information in this kind of research. Lapidaries, habituated to fashion hard stones, are very capable of determining,

mining, with precision, the comparative hardness of these natural compounds. Tables of the hardness of stones are already successfully constructed after their relation, and their experience.

C. *Transparency.*

14. EVERY stone is transparent in its ultimate particles, and it is particularly in this character that these bodies differ from the metals which are totally opaque. But the different manner in which their particles are arranged, with relation to each other, causes this property to vary extremely. Thus there may be distinguished in stones the perfect transparency, that which is cloudy, icy, striated, semi-transparent, and the more or less considerable opacity; impurity or mixture is often the cause which diminishes or takes away the transparency, and it has been thought that a stone, formed by the mixture of several others, must be entirely opaque.

15. By making use of transparency as a distinctive character of stones, it is necessary to give to this character only the degree of confidence or of value which it merits. Frequently it only serves to distinguish varieties; sometimes it may mark a limit in two species, but it is only by associating it with several other properties or characters which strengthen it, that

that the outlines of the description can be completed, which it is always proposed to form in describing these beings.

D. *Refraction.*

16. NEWTON, in his illustrious researches concerning light, has considered with the sagacity of genius the course and deviation which light undergoes within transparent bodies; he paid some attention to stones. Many other natural philosophers have attended to the double refraction which several stones present; that is to say, the property of doubling the image of one object observed through the two opposite faces of a transparent stone. Citizen Haüy has discovered this property in a great number of stones, and has ably explained its mechanism.

17. It is to the interior structure, or to the respective position of the plates which form stones, that the double refraction, which some of them present, is owing. Those which possess it may be distinguished by that singular property, from the species which do not present this character, and which may resemble the former by other characters.

E. *Electricity.*

E. Electricity.

18. STONES appear generally to act in two manners with regard to the communication of the electric fluid. Either they themselves become electric by mere heating, when penetrated by a sufficient quantity of caloric, or else they only acquire that property by friction, or immediate communication with a body already electrified.

Some of them easily become very good electric conductors on account of the metallic matters which they abundantly contain. Nothing more is then required but to place them in contact with an electrified conductor, and to oppose the finger or a metallic ball to it in order to draw sparks from it.

19. It is unnecessary to describe minutely the different modifications of the electric property; it is sufficient to know that they form useful characters to distinguish them from each other, as well as to dispose them methodically among each other: a specific distinction, and methodical disposition which constitute the double object of the natural history of stones.

F. Magnetism.

20. MAGNETISM takes place in several stones; some of them obey it in a remarkable manner,

manner, on account of the quantity of iron in an almost metallic state which they contain. A magnetic bar suspended by its middle on a pivot, and rendered very movable by that suspension, serves advantageously to determine the presence of that property in stones. This character being very proper to establish a certain distinction, should never be neglected.

21. By observing it with attention, on comparing together the stones which possess it, it is soon discovered that it scarcely ever takes place but in those, the opacity and grain of which announce a mixture more or less imperfect; so that it is to the molecules of iron, disseminated among those of the stone, that it is proper to attribute the cause of the phenomenon. Hence it will be conceived why, besides the stones of which I am about to speak, some of them exhibit absolutely the same properties as the loadstone, especially the polarity, and consequently the penetration and the magnetic currents. This last mode, namely, polarity must constitute one of the best means of distinguishing the stones among which it is met with, from those which are simply magnetic, or attractable.

G. Colour.

22. COLOUR is almost, not to say always, an accidental quality, a fugitive property, an inconstant modification in stones. In fact, those

those which seem even to receive from it the most certain character, such as the gems, are frequently without colour, though possessing all the other properties which characterise them, or which determine in them this or that nature, and consequently this or that denomination. Thus it is that we see among the varieties of several species of stones ordinarily coloured, varieties which are clear, or absolutely without colour. We may, therefore, assert with confidence, that the colour originates from particles foreign to the nature of the stone, which may be absent without changing that nature, and without which the stone would continue to present all its distinctive characters. Hence the colour can be but very seldom reckoned among the essential characters of stones, and though it be necessary to indicate the predominant colour in the species, as the green in the emerald, the blue in the sapphire, or the blue telefia, it is proper to rank it rather among the modifications than in the order of the essential characters. Besides when the colour is taken as a character, we use a vague and uncertain property unless instead of a definition we give a fixed example, either by mentioning a natural substance, or by presenting, by the aid of painting, the same tint as that of which we mean to speak.

H. Taste and Smell.

23. TASTE and smell do not exist in any of the stones; and these are, in general, very rare properties among these natural compounds. There are, however, some clays and some filices which leave on the tongue a peculiar faint taste, which may be placed among the essential characters, since this kind of action on the organs of taste only takes place in two species. The case is the same with the smell. It is not to be met with but in the same stones; it is sufficient to impregnate them with the hot vapour of the breath, in order that they may expand this very sensible odour of moist alumine, which is commonly named the earthy smell, and which leaves no doubt concerning the property which that earth has of elevating itself in the air with the water which attracts it. A fetid odour is also observed, in some mixed stones, analogous to that of sulphurated hydrogen gas, and very different from the earthy odour, properly so called.

Characters taken from the Geometrical Properties of mixed Stones.

24. THE properties which the naturalists name geometrical in minerals may be referred
to

to four modifications: A, the external form; B, the internal form, or the nucleus; C, the primitive form, or that of the integrant molecules, on which depends D, the fracture, or the diversity of the surfaces, which are observed in the fragments. Each of these forms being more or less regular, is capable of being defined with precision, or measured with exactness, so as to afford useful results in the study of stones, without furnishing, however, very sure insulated characters. The French mineralogists have greatly advanced the science under this point of view; it is therefore useful to exhibit an outline of their doctrine, at the same time remarking that what will be said here concerning stones is applicable to all minerals in general.

A. *External Form.*

26. If ever so slight a view be taken of a collection of stones, it is discoverable that a great number of these mineral compounds affect regular forms, or present crystallizations more or less varied. The first idea which naturalists must have had was that the crystalline form was constant, that it could afford a means of classing and of distinguishing the stones at once, and that it was attached in some sort to their intimate nature. Linnæus beheld in the crystallization of stones an analogy with the organic forms of plants and of animals. According

according to him, the crystalline form, impressed in some manner among them by the salts, represents a species of fecundation operated by saline substances, and he believed that it may serve to dispose them methodically like the sexual organs in plants: he then established a mineralogical method from the form of stones, by deriving their generic denominations from the salts, which he regards as their generators. Thus the diamond was, according to him, a species of alum, rock crystal a species of nitre. But Linnæus himself perceived that there were many errors in his system, because he separated, in different genera, varieties of the same substance, as the calcareous spar, and he connected in one genus very different stones. This celebrated naturalist besides was acquainted with but very few crystals, and even with them only in a very inaccurate manner.

26. Romé de Lisle studied with extreme care, and collected with indefatigable patience, an immense quantity of stony crystals. He discovered the variations, and even the apparent contrasts of crystallization of the same substances. He reduced the diversity of forms to general or primitive types. He admitted and exhibited a predominant form in each genus, composed of all the substances of the same nature, and he described the various modifications under which that form appeared to be masked; he determined even the gradation, or the series of transitions between that form and

that of the polyhedra which appeared to differ most from it. He first discovered that, notwithstanding the diversity of form which the same stony substance affected, the character might be discovered and determined within a certain point, by the constant value of the principal angles. Lastly, he explained the production of the principal crystalline polyhedra derived from a primitive form by truncatures; and though this last method was erroneous, it is just to say that this work of Romé de Lisle is one of the most beautiful and most useful researches which have been made in mineralogy.

27. Citizen Haüy, by studying after Romé de Lisle, the manner in which the forms of stony crystals are modified according to what he called the laws of diminution, which will be spoken of in the following article, and by reviewing all the modifications of which the external form is susceptible, has proposed some general results, immediately applicable to the considerations which are to be presented here.

28. The crystalline forms of stones cannot serve as characters to distinguish their species. Stones do not universally nor always affect these forms: the numerous metamorphoses which their crystallization undergoes, prevents us from finding in their configuration any common point of union, proper to connect those together which belong to one species. It is not proper, however, to neglect the study of forms

in stones ; it is necessary to remember, that all the crystals of one species, having analogy by the number of their planes, and of the sides which terminate these planes, as well as by the mutual disposition of the same planes, have, at the same time, their angles constantly of the same measure, in such a manner that one only, however modified it may be, may represent all the others. From this first truth, demonstrated by the researches of Romé de Lisle, it follows, that it is possible to determine, from the mere measure of angles, all the varieties of stony crystals comprised under one species, or to ascertain that two analogous forms of stony crystals belong to different species, if they differ in the measure of their angles.

29. If the identical forms, such as the cube, the regular octahedron, the regular hexahedral prism, &c. which are met with in very different species, be opposed to the certainty of thus distinguishing mineral bodies, and to the establishment of a method founded on crystallization, it will then be sufficient if we combine, with this first character of form, a second character easily to be ascertained, in order to derive an advantageous use from our observations concerning the stony crystals. Thus, though the exterior form does not truly represent, but in very few cases, the species among stones, sometimes it is alone sufficient to indicate them, and in others it only requires to be joined to some

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other

other consideration, in order completely to distinguish the species.

30. The habitude which is acquired by a long practice is necessary to discover the forms of stones which are not very evident, particularly when the stony crystals are grouped or close to each other, or concealed partly in the gangue; it is necessary to measure the plane angles, and the respective inclination of their faces or edges. This measure is made with an instrument, which is named the goniometer, and of which a description is found in the *Journal de Physique*, and in several other works on mineralogy.

B. Form of the Nucleus or internal Form.

31. THE external form, or apparent crystallization of minerals, of which we have just spoken, is frequently, and almost always, a mere outside which covers a primitive form, and varies according to certain laws, whilst the internal form is constant. Bergmann, by studying the mechanism of the form of crystals, was the first who considered the different forms of the same substance as produced by the superposition of planes, regularly decreasing around a crystalline nucleus of a constant figure. This original idea, verified by the celebrated chemist of Upsal, upon a variety of fractured calcareous spar, was afterwards taken up and singularly extended by citizen Haüy, who applied

applied it to a series of crystallized minerals, who generalized it by a very great number of ingenious researches, and who discovered the natural laws of the diminutions, both by experiment and by calculation, in such a manner as to render that discovery absolutely his own; particularly as it was a fortunate accident of the fracture of a crystal which presented it to him, when he was yet absolutely ignorant of what Bergmann had done before him. This new branch of the study of minerals, which constitutes, in its practical or experimental part, a true crystallogotomy, and in its theoretical researches a crystallogometry very different from the incoherent, vague, and frequently erroneous notions which were maintained before the discoveries of citizen Haüy, now present a number of general principles which may be explained in a few words.

32. When the accidental fractures, which are formed in stony crystals by the shocks which they receive, are considered, it is remarked that they take place in directions peculiar to each kind of crystallized substance. If it be attempted to divide or dissect the crystals with the blade of a knife, by cautiously striking or pressing on these crystals, a practice which resembles the art of cleaving stones, so well known to lapidaries, it is also observable that they only admit of that dissection in particular directions; this direction is discovered by the facility of detaching the plates of the crystals,
and

and by the polished, smooth and brilliant surface of these plates. By this species of anatomy, we are enabled to derive, or to extract, in some degree, from a polyhedral exterior, a solid different from the former, which frequently appears to have no relation with it, and which was included or concealed under a superadded envelop; thus a cube is extracted from an octahedron, from a dodecahedron, an octahedron from a cube, a rhomboid from a prism, or from another species of rhomboid, &c.

33. All minerals, and in particular all the stones, do not appear equally subject to this mechanic division; but not to mention that experience proves that there are a much greater number of them which admit of it than could at first have been imagined, this imperfection is supplied in the direct examination of their structure by observation of the striæ which furrow them, the position of the faces which violent fractures uncover, or their analogy with other divisible crystals.

It is ascertained that all the varieties of exterior form, presented in the different modifications of the same substance, or of one substance of the same nature, approximate by dissection to the same internal form, to the same identical nucleus, provided with the same number of faces equally inclined to each other, and joined by the same angles. Hence, the denominations of *primitive form* for the internal nucleus, and of *secondary forms* for those which differ

differ from the former, and are produced by the addition of plates, decreasing according to laws which have been determined.

34. As these two forms, which are frequently superadded to each other, present varieties of figure, which are sometimes very numerous in the same substance, all these varieties may be considered under a geometrical point of view, as composed of a constant quantity, which is the nucleus, and of a variable quantity, which forms the envelop. Nothing more remains to be done, after this consideration, than to find the law of the variation.

If the figures of the plates, superadded to the nucleus, be observed, it will be seen that these plates decrease sometimes in all the sides at once, sometimes on particular sides only, so that the diminutions have for the limit of their departure, or origin, sometimes the edges of the nucleus, and sometimes the angles. Now it is on this diminution, whether partial or total, that all the varieties of secondary form depend. The problem which must be proposed to discover the generation of each of these forms, may be proposed in the following terms: *a secondary crystal being given, as well as the figure of its nucleus, and that of its particles, (supposing, moreover, that each of the laminæ superadded to the nucleus be exceeded or overlapped by the preceding laminæ, in certain parts, in a quantity equal to one, two, three rows of particles); to determine among the different laws of diminution*

nution, that from which a form shall result perfectly similar to the one proposed, in the number, the figure, the disposition of the faces, and the measure of the plane and solid angles. By calculation, applied to each case of secondary form, a law of diminution is formed, which answers the conditions of this problem,

35. The varieties are also rendered more evident by arranging solids of a sensible volume taken for the integrant particles, about a larger nucleus, in such a manner as to present to the eye a gross but accurate view of the dispositions of the plates on the faces of the nucleus, and of the production of the different secondary forms by the diminution. A series of these models of structures, of these dissections of crystals in wood or in pasteboard, has been made by the care of citizen Haüy, and it is possible, in proportion as any new form is known in its generation, to present its type to the eyes of observers. Nothing more is required than to reduce these gross solids, by imagination, into imperceptible particles, in order to refer the artificial structures to the natural. In this manner it is shown, either by calculation, or by dissection, or, lastly, by the model, 1st, that a dodecahedron, with equal rhomboidal faces, has for its nucleus a cube, on each of the faces of which there are a succession of square plates, each decreasing by a row of particles on each side, in such a manner that they form quadrangular pyramids, placed on each face of the cube, and

and as the fix pyramids have twenty-four triangular faces, two of which lie in the same plane, there results from them a secondary solid, having twelve equal rhomboidal faces; 2d, that a dodecahedron, having pentagonal faces, results from a diminution of square plates on a cubic nucleus, by two rows in breadth on two of the sides of the nucleus, and by two rows in height on the two other sides, &c. &c. All the possible variations may thus be explained; but these are the general principles which we seek, and it is only necessary to develop the results to which these principles lead.

36. To explain the possible varieties of crystallization by diminution, it is necessary to understand, 1st, that the diminution may take place on the sides, by one, two, three or four rows of particles: 2d, that they may take place on the sides alternately in height and in breadth, and with differences in the number of rows withdrawn; 3d, that they may take place by the angles; 4th, that the different diminutions may be combined two and two, or in a greater number, in such a manner that the varieties of forms possible to exist, or determinable by calculation, are infinitely more numerous than they have yet been found in nature; 5th, that there is sometimes an uniformity between all the decreases, in such a manner that they take place by one, two or three rows on different sides or angles, and sometimes they vary from one side to another, or from one angle to another;

ther; 6th, that sometimes the same side or the same angle undergoes several laws of decrease which succeed each other; 7th, that the number of the laws appears nevertheless to have a limit determined by the circumstances under which crystallizations are placed; for example, the diminution has not yet appeared to exceed six rows of particles; 8th, lastly, that there are cases where the law of the diminution is interrupted at a certain height of laminæ added to the primitive form, or to the nucleus, in such a manner that there then exists, in the secondary figure, forms parallel to those of the nucleus.

37. To the bases of the theory, published by citizen Haüy, it only remains to add the number of the primitive forms, or of the different nuclei, which crystallotomy has hitherto enabled us to discover. It is found, at present, that all the primitive forms are reducible to six, namely, 1st, the parallelopipedon, such as the cube, the rhomboid, and, in general, all the solids terminated by six faces, parallel two to two; 2d, the regular tetrahedron; 3d, the octahedron with equilateral isocèles or scalene triangular faces; 4th, the hexagonal prism, with a regular or simply symmetrical base; 5th, the dodecahedron with equal rhombic faces; 6th, the dodecahedral form of two right pyramids united by their bases.

C. The Form of the primitive Integrant Particles.

38. THE most difficult question to discuss by experiment, and which it is scarcely possible to solve but by reasoning, is that which relates to the form of the primitive particles, or of the last integrant particles of minerals in general, and of stones in particular. It is true that the solution of this question has but little relation to the classification and to the method of distinguishing stones, since the forms of the primitive particles, even when its precise determination shall be attained by long and difficult labour, will not serve as characters for stones; it is only requisite therefore, to treat this subject concisely, merely to know how far we have arrived in this respect.

As the internal nuclei of minerals regularly crystallized, however multiplied the internal forms which envelop them may be, are reduced to six polyhedra, so likewise are the primitive particles which constitute these figures, which are so minute that they escape our senses, and appear to be reduced to a still smaller number of elementary forms. Some attempts at the dissection of primitive crystals seem to announce that the tetrahedron with triangular faces is the most frequent primitive form of the particles; to these may also be joined, in thought, the triangular prism and the parallelopipedon. Tetrahedrons,

hedrons, arranged in a great many different manners, give every possible form, as may be seen by the artificial generation of parallelopipeds, from laminæ by every kind of superposition, of octahedrons, of dodecahedrons, of rhomboids, &c. It is evident then that the tetrahedron may be supposed the only primitive form of the particles, generating every other form, as well in the nuclei as in the secondary and external crystallizations. In this probable hypothesis, which is consistent with the simplicity and economy of nature, the constant and given forms, both of the nuclei and in the secondary crystals of the same substance, depend only on the respective disposition, or the particular arrangement of the primitive particles among themselves. It is in the disposition, and the arrangement of these particles, which always takes place in the same manner in the same substance, that the geometric character of each substance consists; and this character, or that limited disposition of particles, depends on the proper or chemical nature of mineral bodies. From this important consideration the form of the primitive particles, besides that it is difficult and almost impossible to be discovered, cannot serve as characters to distinguish stones; it is their respective arrangement only which can assist in this distinction; and as this arrangement is determined by the inspection of the fracture of minerals, and particularly of stones,

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it is concerning the fracture which it is necessary at present to treat.

D. *Fracture.*

39. WHEN any stone is broken, we observe, in the surfaces concealed by nature, a peculiar arrangement of their integrant particles, a distinct species of texture in each. It is this appearance which lithologists describe under the name of fracture; it affords characters very useful for the distinction of stones from each other. On comparing all the observations made concerning the form and aspect of the internal part of all known stones, it is evident, that it is possible to reduce the differences of fracture which these matters present, to certain distinctions. In fact, some present, like glass, surfaces smooth, polished, and undulated in their fracture. This character constitutes the *vitreous* fracture; it is very marked in quartz, agates, &c. Others present a half-clear and polished surface in their fracture, but which is not equal in all the places of separation; it is formed of portions successively round and concave, and the two portions which approximate reciprocally, cover each other in the manner of small flates; this appearance is called the *scaly* fracture; these species of concave and convex scales are sometimes broad and long, sometimes narrow, round, elongated, superficial, hollow, &c. They are
met

met with in the different kinds of flint, jasper, and petro filex.

There is another class of stones which, when broken into fragments, exhibit in the surfaces newly exposed, a number of small, jutting out and round points, similar to grains of sand worn by waters. This form is called the *granulated* fracture; it may be very easily observed in grit-stones. The coarseness, the fineness, the varied surfaces of these grains, present also a considerably great number of differences which may be useful to serve as the distinctive characters of many stones. It is from this species of fracture that the figurative name *paste* is sometimes given to the interior part of stony matters; they are, also, sometimes described under the name of *grains*.

There are a great number of stones, the broken surfaces of which present polished shining plates, placed so as to cover each other, like horizontal beds. Most of those have been called *spars*, this form is called the *sparry* texture. These plates differ from each other as to their extent, their height, their thickness, their transparence, or their opacity, their horizontal or oblique position, relatively to the axis or the diameter of crystallized stones; for they announce a true crystallization, when they are brilliant. If they do not possess the *chatoyant* or variable shining aspect, the fracture which they form is merely *lamellated*. When the plates, or the joints, are not continued, but confused, this texture is named
plated

plated or scaly. It is the respective disposition of these plates, so varied in the gems, the calcareous, vitreous, and heavy spars, which occasions the shining chatoyant aspect which is observed in talc, feldt-spar, and its different species, such as the opal, the natural aventurine, the Labrador stone, &c. Lastly, some stones present a fine and close grain, with a dull or mat appearance, and this is what is described by the name of *argilaceous fracture*.

Some authors have made use of the general form combined with the fracture, for the arrangement of stones. Cartheuser, in 1775, has given a system of mineralogy in which he distinguishes stones into lamellated, fibrous, solid, and granulated; but the fracture alone cannot serve for the establishment of a complete method of lithology, and it is necessary that it should be combined with all the other characters which are here treated of, in order that it may become truly useful in lithological distinctions.

*Characters taken from the Chemical Properties of
Stones.*

40. I DESCRIBE, under the name of chemical properties or characters of stones, all the phenomena which they present when treated by any process which changes their composition, which alters their natural combination, which modifies, in a word, the mode of union of their principles,

ciples, either by combining them otherwise than they were in their earthy compounds, or by separating them, or attempting to separate them in such a manner, that it effects a more or less complete analysis. There are three principal effects which take place in either of these actions, and which mineralogists have been accustomed to borrow from chemistry, in order to assay and distinguish stones from each other; namely, the action of heat alone, the action of heat with the addition of fluxes, and that of acids. It will be observed, that the chemical properties which are treated of here, are only the rapid products, or the almost instantaneous results of some easy and quick operations, of some slight essays which are made on the fragments of stones, sometimes very small, which, though they may conduce to the knowledge of these fossil compounds, principally as to their classification, are far from giving a sufficient idea of their nature, and cannot be compared with their analysis, which will be spoken of hereafter.

A. The Action of Heat alone.

41. STONES are assayed by heat in two manners, namely by heating them more or less strongly and for a long time in crucibles; this method, which can only be employed in a laboratory, is but seldom within the power of the lithologist, and rarely makes use of it. The other
process

process consists in treating them by the blow-pipe, an ingenious instrument from which Bergmann first derived great advantage in the study of minerals, and which joins to the convenience of a small size, and to the facility of being everywhere transportable, the advantage of operating on very small fragments, of exposing stones to the action of a most violent heat relatively to the small mass which is heated, and of affording very quickly a result which is always satisfactory, and almost always contributes to the knowledge and the determination of the species of the individual which is exposed to its action.

42. The fragments of stones thus treated, either remain perfectly unalterable, or lose their hardness, their transparency, their form, their colour, become friable, are divided, split, fly asunder, decrepitate, or melt, vitrify, boil, remain in tranquil fusion, afford glasses either white, transparent, opaque, solid, porous, cavernous, smooth, coloured, dark, shady, striated, homogeneous, &c. All these gradations of phenomena are so many means of discovering and of estimating the differences of stones among each other, and mineralogists have made great use of it since the time of Bergmann.

B. Action of Heat with Fluxes.

43. THE stones are acted on very differently by heat, with the addition of various saline matters,

ters, than by heat alone. The principal effect of these matters being to assist their fusion, they are, on this account, named fluxes. Frequently a stone, which alone does not present any alteration by the influence of heat, is more or less considerably affected when heated with a fixed alkali, or with one of the salts which will be described in the following section. The manner in which each of the stones is affected when it is heated with different fluxes, its fusion more or less quick or slow, easy or difficult, complete or incomplete, liquid or pasty, the kind of mass which results from it, opaque, transparent, vitreous or enamelled, scorified, or dense and compact, the colour which it principally affects, and which almost always depends on the nature and the proportion of the metallic matters which it contains—these form so many useful characters employed by mineralogists to discover and distinguish each species of the several compounds; and when the external characters or the sensible properties do not suffice to determine with accuracy the species, this action of the fluxes employed with the blow-pipe is frequently useful to that determination by removing doubts, destroying uncertainties, and explaining the nature of the species.

C. Action of the Acids.

44. THE action of the acids is, in general, very weak on most stones. It was formerly thought

thought of use in characterizing them, when a number of saline substances were placed among these bodies, the bases of which are earths, or acidiferous earthy bases as the modern French mineralogists have named them, because a stronger acid, by driving off a weaker from those, ordinarily disengages it under the form of globules, and with a frothy motion called effervescence. But it is no longer by this property that the acids can be of use to lithologists, since the exact discoveries of chemistry have removed, from the class of stones, and referred to that of saline bodies, these pretended effervescent stones. There remains then, for the action of the acids, only two effects, or rather two opposite phenomena which they produce on stones ; either they are perfectly and completely unchangable ; or they become more or less quickly destroyed and dissolved by these agents. Most frequently, this last alteration takes place only in the course of time, permitting the acids to act slowly on the stones which are immersed in them : whence it follows, that this use of the acids is little advantageous to lithologists, who wish to see an effect which can be quickly appreciable. It is much better appropriated to the analysis of stones, as I shall explain at the end of this article.

SECTION SECOND.

Concerning the Lithological Methods which are founded on the Physical Properties.

45. THOUGH the sensible differences which exist between different stony fossils, may be less numerous and less evident, at first sight, than those which are observed between the species of organized vegetable and animal bodies, yet when we examine them with attention, it is evident that they are sometimes sufficiently definite and multiplied, to be useful in discovering and distinguishing them. This was accordingly the first method adopted to characterise and arrange these productions of nature. The first notions also, which men have adopted from necessity concerning the different properties of stones, may be regarded as the early sketches of lithological methods. The treatise of Theophrastus on stones is a sketch of this description.

46. In the time of Pliny, stones were even then distinguished from salts, from bitumens, and from metals; and a division into four classes already existed. The electric property of amber, and the attraction of iron by the loadstone were known: already the stones formed distinct groupes. The marbles and the gems were separated; the hard and the soft stones.

Pliny

Pliny has well described the form of crystal, and the general phenomenon of the crystallization of fossils did not escape him. Antiquity, however, did not possess one true notion, nor one positive idea of the methods of natural history, their advantages, and their necessity.

47. It was in the eighteenth century alone that the denominations of kingdoms in natural bodies was adopted, that the mineral kingdom was particularly admitted, that mineralogical methods were imagined, and the distinctive properties or characters sought, in order to class and distinguish the different species of stones. It was natural at first to take, for these characters, such properties as are the most apparent, the most sensible, and the most easily observed, and that lithological methods in particular should be founded on what are called external characters; that is to say, on the properties which these compounds present to our senses, without causing them to undergo any alteration whatever.

48. In running over the different classifications of minerals proposed successively by Bromel, Cramer, Henckel, Wolsterdorff, Gellert, Cartheuser, Justi, Lehman, Vogel, Scopoli, which were all more or less established on the sensible characters which the eye could discover in these bodies, it was soon known that the distinctions at first admitted would be insufficient to distinguish them without error, and that they were more adapted to approximate dissimilar,

diffimilar, and to separate similar substances from each other ; or to confound for a long time, the science of regularly arranging these compounds, with the art of merely characterizing them, or merely knowing them at sight. The same error has been committed as in all the other parts of natural history, because the endeavour to afford means of distinguishing them has been accompanied by an attempt to combine their classification and arrangement with the pretended relations which were sought for between them.

49. This singular pretension, which has done much injury to the progress of the science, is exhibited more particularly in some lithological systems, by naturalists, who consider stones only with regard to one of their properties ; they have wished to draw, from this single consideration, an order which they pretend is natural for their relative disposition, and a method, which they assert, is easy to distinguish them from each other. Such have been, among the labours of the most illustrious modern mineralogists, the systems of Linnæus and of Romé de Lisle. These two able naturalists have established their classification as well as their distinctions between stones, on their crystalline form alone. The first, guided by a philosophic view, indeed, has given only an imperfect and erroneous sketch, which, without being useful in the real knowledge of stones, has however been the source of the greatest discoveries concerning crystallization. The second, after an immense labour on the crystalline forms of stones, and their varieties,

ties, has so multiplied the distinctions, the species, and the varieties, that, notwithstanding his indefatigable activity, his accurate descriptions, and his methodical progress, those who have followed him have not been able to consider his work in any other view than as a source of materials. The fate of these two systems has proved that a single geometric character is insufficient, either to class stones, or specifically to describe and distinguish them.

50. Instructed by the insufficiency of this systematic course, and guided by a light less deceitful and uncertain, other able mineralogists have happily perceived that no single property can be of use to establish real distinctions among stones; that it is necessary to distinguish carefully the system which, by common characters, seeks to arrange these compounds with each other, from that artificial method, of which the aim is to teach the means of distinguishing them unequivocally and without error. They have happily associated and compared all the apparent or sensible properties of stones; by opposing, and contrasting them with each other, they have established characters proper to distinguish these bodies; they have given a kind of portrait, by decomposing, in some measure, all the traits of their physiognomy; and their outlines, which have the strongest resemblance, are then considered as answering the intended purpose. Such particularly are the methods of Wallerius, and more especially of Daubenton and Werner.

51. These

51. These two last mineralogists have especially availed themselves of the hardness, the brittleness, the transparency, semi-transparency, or opacity, the form, fracture, grain, colour, apparent texture, the surface, whether dull, smooth, bright, chatoyant, the disposition of the laminae, the direction of the plates, dissection, electricity or magnetism, appearance and colour of the produce, specific gravity, &c.; in a word, of all the properties which can fall under the senses, and are not calculated to produce error or uncertainty.

52. But, however advantageous this method of characterizing stones may be, which is evidently reducible to a clear analysis of their physical properties, whatever may be the facility it affords of distinguishing each kind of stone by reducing it to its just value, we must by no means forget that it cannot be applied for disposing these compounds in a natural order; that it will never serve to indicate their intimate nature or composition; that it is not capable of answering its own peculiar object, unless a faithful enumeration of all the properties of each individual stone be given; and that otherwise we should constantly be in danger of confounding the stony compounds with saline or metallic matters, as has happened with the most skilful nomenclators; and that the method must consequently be considered only as an approximation. It is, in fact, a table by the help of which we may find the object intended to be studied; but which can never dispense us from the
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the necessity of investigating the properties and intimate nature, if we are desirous of knowing the body we examine, and particularly to determine the uses to which the stones may be successfully applied.

SECTION THIRD.

Concerning the Lithological Systems founded on the Nature or the Composition of Stone.

53. IT was undoubtedly because the study of the physical properties, or the external characters of stones soon convinced lithologists that these properties, far from conducing to the exact knowledge of fossils, were only capable of giving false ideas, and producing errors respecting their composition; that several authors adopted the project of classing them according to their combination or their intimate nature. Cronstedt is the first who executed this plan, and who proposed to establish distinctions between stones founded on the nature and proportion of their constituent principles.

54. This happy thought, which forms the only real foundation and solid basis of lithology; which, from the mere art or the routine of distinguishing and naming them, elevates it to a true science; this happy thought, since the time of that first Swedish mineralogist, who has traced a sketch of it, has much engaged the attention of chemists, who have successively contributed to

to extend, to improve and to complete it ; and this great labour is not yet terminated, notwithstanding the numerous researches which have been made, without intermission, since the time of Cronstedt. It is to the series of analyses, made since the middle of the eighteenth century, for the analysis of stones, and for the construction of a true lithological system, that we owe a great many discoveries ; by the aid of which the opinions of mineralogists have been gradually rectified, and a number of saline or acidiferous metallic substances removed from the class of stones.

55. The course first opened by Cronstedt has been since followed with great success by Bergmann, by M. Kirwan, and by De Born. These illustrious philosophers, by carrying the light of chemistry into the study of minerals in general, and of stones in particular, have established lithological systems, in which the stones are arranged according to the principal earths predominant in each. Thus it will easily be conceived that it is possible, by taking for the chemical character the earthy matter most abundant in stones, to form of them as many genera as there are earths, which may in effect constitute their base ; thus we may understand what Bergmann and Kirwan have denominated the siliceous, aluminous, magnesian, calcareous, and baritic genera. We may advance further than they, in thought, by admitting as possible the zircon, glucine and strontian genera.

56. A defect, not to say an error, which some able mineralogists have not been able to avoid, because they have permitted themselves to be led by the habitual opinions of those who have preceded them, and because they have not confined their progress within the severe limit which method imperiously prescribes, at present, to those who follow it, is, that they have confounded among the stones, by thus taking for the type of each genus a particular earth, the greater part of the saline compounds which the modern mineralogists, enlightened, indeed, by the strict analyses which have been lately made, arrange in a class apart from their system under the name of acidiferous substances; and it will be seen hereafter that it is still more immediately necessary to separate these bodies from stones in a treatise of chemistry.

57. The lithological systems which are here considered, must still be regarded only as attempts, because the analysis of stones is very far from being carried so far as to enable us to compare the nature of each of them, and consequently to dispose them all in a determinate series by the order of their composition. It is for this reason that, notwithstanding the efforts of the three authors here mentioned among the moderns, there is not yet any relation, or connection between the received notions, the names given to stony compounds, and the nature of these fossils which is still, in many instances, only in part known.

58. If

58. If we compare the lithological systems, founded on the composition, and the appreciated nature of stones, with the methods derived from the physical properties,—while we observe that the former are alone capable of affording a true notion of these productions from the nature, as well as from the laws which it follows in their formation, their changes, and the formation of their varieties,—it will, nevertheless, be seen that these systems can never supply the uses of the first methods; that they will never afford the means of distinguishing stones from each other by inspection, or of teaching to determine their species by the eye; and hence that these two kinds of considerations ought to be associated with each other to complete the regular system of the classification of stones, and the proper method of knowing them. Such is the proceeding adopted in the actual state of mineralogical science; a course of which it will be useful to exhibit a slight sketch in this place.

SECTION FOURTH.

Concerning the Distinction of Stones admitted in these latter Times by the French Mineralogical Schools.

59. THE number of fossils which were comprehended in the class of stones, being formerly much more considerable, genera and species were established

established in this order of substances ; and this distribution was founded, sometimes on the intimate nature or the chemical properties, sometimes on the apparent or physical properties only, sometimes even on both jointly. At present, as the new order adopted in mineralogy excludes from the number of stones all the earths or bases in general that contain acids, and presents these in particular under the name of acidiferous substances, the French mineralogists do not regard as real stones, nor comprehend under that denomination any earthy substances, except pure assemblages or combinations of earths. Hence the number of these natural combinations, which constitute stones, are found to be so diminished, that it is no longer necessary to establish genera among them, nor all the distinctions which were formerly indispensable.

60. It is for this reason that, in the last method adopted by the School of Mines de France, and presented by Citizen Haüy, in the Extract from his Elementary Treatise of Mineralogy, the number and the proportions of the earths essential to each of these substances, not having been yet sufficiently explained by analysis, this philosopher presents merely a series not subdivided into genera, and simply avails himself, in the arrangement of that series, of the relations or the differences of nature, which can be estimated by observation between the substances which constitute it.

61. According

61. According to this proceeding, he has distinguished forty-five species of compound earthy substances, or of stones under names partly old and partly new ; these last being founded on the best known properties of these bodies. The forty-five substances are successively placed in the following order :

1st, Quartz.	24th, Smaragdite.
2d, Silex.	25th, Oisanite.
3d, Zircon.	26th, Diopside.
4th, Telesia.	27th, Lazulite.
5th, Cymophane.	28th, Zeolite.
6th, Ruby.	29th, Stilbite.
7th, Topaz.	30th, Prehnite.
8th, Emerald.	31st, Chabosie.
9th, Euclase.	32d, Analcime.
10th, Garnet.	33d, Sommite.
11th, Leucite.	34th, Andreolite.
12th, Idocrase.	35th, Peridot.
13th, Feldt-spar.	36th, Mica.
14th, Petro-silex.	37th, Cyanite.
15th, Corindon.	38th, Tremolite.
16th, Ceylanite.	39th, Leucolite.
17th, Axinite.	40th, Dipyre.
18th, Tourmaline.	41st, Asbestos.
19th, Amphibole.	42d, Talc.
20th, Actinote.	43d, Chlorite.
21st, Pyroxene.	44th, Macle.
22d, Staurotide.	45th, Argil.
23d, Thallite.	

We will proceed to give a short notice of each
of

of these earthy substances, and of their specific characters.

62. *Quartz*: a hard scintillant stone, scratching glass, with a brilliant undulated vitreous fracture, having double refraction in its transparent varieties, the primitive form or the nucleus of which is the pyramidal dodecahedron, and the integrant particle the irregular tetrahedron, very hard and difficult to cut, receiving a beautiful polish, infusible and incombustible, phosphorescent by rubbing, the specific gravity of which is between 25813 and 20701. It is named rock crystal when it is under a regular form; it presents a great number of varieties in its forms, its colours, and the mixtures of metallic oxides. The names of its principal varieties, are either the denominations from the colours substituted instead of the old names, such as red quartz instead of the hyacinth of Compostella, the ruby of Bohemia and the Sinople; violet quartz instead of the amethyst, blue quartz instead of the water sapphire, yellow quartz, instead of the occidental topaz, green instead of prase, &c.; or they express the relations of surfaces, or apparent figure, such as those of the primitive rhombiferous, plagihedral and lenticular quartz; or accidents, or mixtures, such as the words milky, smoky, iridescent, micaceous, amyanthean.

The grits are removed from the species of quartz, because they are aggregates of agglutinated fragments, species of breccias, or pudding

ding-stones, which ought not to be reckoned among primitive stones.

The most abundant component part of quartz is flint; it is found united frequently with a little alumine, and sometimes with iron, or some other metallic oxides.

Besides the ornaments and the jewels to which these rare and beautiful varieties of quartz are appropriated, its common varieties are applied to a number of different purposes.

63. *Silex*: a hard stone always opaque, or very slightly transparent, more or less coloured, scratching glass, and sometimes quartz, specific gravity between 2,4 and 2,6, scintillant, never crystallized, of a texture frequently vitreous, sometimes scaly, conchoidal, or undulated. The agates, and the jasper in which the siliceous matter is mixed with clay and oxide of iron, which renders it a conductor of electricity, are now considered as varieties of this species. The principal varieties of flint are, the common flints of chalk-pits, the light-coloured pebble, or gun-flint, grinding-stone; or rotten quartz, calcedony, the opal, hydrophane, cacholong, the cornelian, the sardonyx, the chrysoprase, the agate onyx, the eyed, herborized, shaded, veined, frothed pebble and agate, the heliotrope, jasper, the enhydrias, the pechstein, or resiniform flint, the menilite or pechstein of Menil-Montant, the red, green, blood-coloured, and party-coloured jaspers. Analysis has exhibited more
mixture

mixture in filex than in quartz, and particularly more of the metallic oxides.

The varieties of filex are cut and polished to form hard jewels and ornaments. They are of use for obtaining fire by the stroke of steel. Mullers, mortars, and other utensils are made of it.

12. The *zircon*: a hard, scintillant, transparent stone, susceptible of a beautiful polish, scratching quartz though with difficulty, having a strong double refraction, of which the specific gravity is between 4,2 and 4,3, and even as far as 4,3858 ; its primitive form is an octahedron with isocetes triangular faces, which is parallelly subdivided into isocetes triangular faces, that pass through the perpendicular of the triangles, and the form of the integrant particles is a tetrahedron. Though this species includes the two stones which are named hyacinth and jargon, the first is itself described under the name of jargon : we say the jargon hyacinth, and the jargon of Ceylon. It appears that this name is derived from its resemblance to the diamond, which it seems to resemble, as the jargon, in false language, resembles eloquence. These species of stones first afforded and still exclusively afford the earth which is named zircon ; because the jargon is called the zircon at Ceylon. The following varieties were discovered by Citizen Haüy, either in the specimens of France, particularly those of the brook of Expailly, or in those of Ceylon.

a. *The primitive zircon*, or octahedron, the form of the integrant particles of which appears to be the tetrahedron from Expailly.

b. *The dodecahedral zircon*, having four hexagonal planes, with summits of four rhomboidal faces, the ordinary form of the hyacinths of Expailly, of Ceylon, &c.

c. *The prismatic zircon*; the primitive form augmented by a prism which separates the two pyramids; it is that of the jargons of Ceylon properly so called.

d. *The amphi-octahedral zircon*; eight planes surrounding the prism, and eight faces to the two summits; hyacinth of a greenish yellow, named chrysolite of Ceylon by some naturalists.

e. *The zonary zircon*: facets forming a zone round the prism.

f. *The plagihedral zircon*: triangular facets, situated slopingly and bearing two against two; jargons of Ceylon.

g. *The quadruple zircon*; a crystal with thirty-two faces, a number quadruple of those of the primitive nucleus.

h. Five other varieties according to the limpidity, or the aurora red mixed with brown, the reddish, the yellowish, and the greenish colours of this stone.

The jargon is a natural compound of zircon, of flint, and frequently oxide of iron. Its species are only of use as ornaments; they are reckoned

reckoned among the precious stones, or crystalline gems.

13. The *telesia*: this new name, of Citizen Haüy, which implies a perfect stone, is given to three of the most beautiful stones, which were formerly comprehended among the precious stones, or gems, namely, the ruby, the sapphire, and the oriental topaz of the lapidaries; because these three stones are of the same species, or approximate each other in all their properties, and particularly in their hardness, their specific gravity, form, and inalterability. The celebrated mineralogist already mentioned, at first named this species *oriental*; it is one of the hardest and most transparent of stones. It cuts all the other stony substances. Its sp. weight is from 3,9911 to 4,2833; its refraction is simple. There are reckoned at least eight varieties; some, derived from the form, and named *primitive*, *elongated*, *minor*, *enneagonal*; others from their clear, red, blue, or yellow colour. The most frequent form is a dodecahedron, or two hexahedral pyramids united, or else a prism having six regular sides, of which the sections, parallel to the bases, are alone very perceptible; this is the primitive form. That of the integrant particles is an equilateral triangular prism. Sometimes these stones are found crystallized of two or three colours in the same piece. Frequently the *telesia* is rounded. It is met with in the kingdom of Pegu; some very

small specimens are also found in the brook of Expailly.

The blue telefia exhibits, by analysis, an enormous quantity of alumine, nearly 0,99. The metallic oxide which is found in the coloured varieties, is only accidental to it, and merely represents the deficiency of the proper matter of the stone. Its use is almost entirely in ornaments, and jewels: jewels or bases for the pivots of watch-work are made of it.

14. The *cymophane*: this name, which signifies *undulating light*, has been given by Citizen Haüy to a stone which approaches to the telefia, but, however, differs from it sufficiently to form a peculiar species. Its name is derived from its presenting milky reflections, mixed with bluish gleams issuing from its interior, and arising, as it would appear, from a slight separation between its plates.

This stone has been falsely regarded as a chrysolite by the jewellers; some naturalists have described it by the name of *opaline chrysolite*, but it differs too much, in its hardness, its form, and its weight, from the chrysolite (which is, at present, referred to its true species, that of the phosphate of lime, according to the discovery of Citizen Vauquelin), to be confounded with it. The name of *chryso-beril*, or of *beril of golden yellow*, which M. Werner has given to it, expresses a colour which it never has, and a relation with the beril, or emerald, which

which does not really exist. The following are the distinctive properties of the cymophane.

Its colour is frequently of a yellowish-green, or the green of asparagus, sometimes approaching the yellowish-brown. Its milky and bluish reflections issue from its interior, and are on a plane parallel to one of the faces of the crystal; it has a single refraction; its specific gravity is 3,7961; it marks glass strongly. Its most common crystalline form is an octahedral prism, with summits having four trapeziums and two rectangles. Its primitive form, as well as that of its integrant particle, is a rectangular parallelepipedon. It appears that a variety described by Emmerling, and the formation of which has been appreciated according to a particular law of decrease by Citizen Haüy, presents a regular hexahedral prism, the base of which exhibits elongated hexagonal tables, having equal angles, indicated by the first of these naturalists. There is a third variety, where the prism has twelve sides, four of its edges being replaced by two elongated facets by virtue of a decrease by three rows in height, and by four in breadth. The calculation from the known forms, as well as the undulated texture, which the plates present in two directions, perpendicular to each other, give for the primitive, or middle form of the cymophane, a right quadrilateral prism, the faces of which form right angles.

The cymophane is distinguished from the tefesia, to which it approaches in hardness, by its specific gravity which is a little less, and by
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its most common forms, and of its joints which are sensibly parallel to the lateral faces ; whereas in the telefia, the joints are parallel to the base of the prism ; the reflections which sometimes take place as well in the telefia as in the cymophane, follow the same variety of directions as the joining of the plates.

M. Klaproth has found in the cymophane much alumine, with a little lime, flint, and very little oxide of iron.

The cymophane has not yet been employed except as a jewel. It is not much valued among lapidaries, on account of its cloudiness which almost destroys its transparency. It comes from Brazil, and from Ceylon ; it is asserted that it is also found near Nertschinsk in Siberia.

15. The *ruby* : there are only the two species of stones formerly named *spinelle* ruby, and *balais* ruby which belong at present to this order ; this stone differs much from the oriental ruby, or the red variety of the telefia with which it has been confounded, and of which it has been regarded as a variety. The ruby weighs between 3,6458 and 3,7600. Its hardness is such that it deeply and easily marks quartz, and itself is scratched only by the telefia ; its texture is vitreous ; its refraction simple. Its primitive form is the regular octahedron, which is frequently found in this stone, but with slight variations ; the form of its integrant molecule is the regular tetrahedron. There are reckoned several varieties of form and colour ; namely,

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ly, for the form, the primitive ruby, the emarginated, the hemitrope; for the colour, the *spinelle* ruby of a brilliant red, the *balais* ruby of a pale-rose colour, the blue ruby, or sapphire of the Germans, the orange ruby named *vermillion* by the lapidaries.

Its analysis, which presented to Citizen Vauquelin, as well as to M. Klaproth, a great quantity of alumine but no flux, and only a little magnesia, has exhibited also the presence of the new metal which he has discovered in red lead, and also in the state of chromic acid as it is in this last. This acid produces its red colour; so that this stone is a chromate with a great excess of alumine.

The use of the ruby is limited, on account of its rarity and its small bulk, to jewels, and watch-work.

16. The *topaz*: the specific name of topaz is, at present, given to stones very different from what was formerly named the oriental topaz, and which is a telefia, as has been seen. The actual topaz, or that properly so called, now includes those of Brazil, of Saxony, and of Siberia. The name of topaz is derived from an island where the stone, so called by the ancients, was found.

The specific characters of this stone consist in its weight, which lies between 3,5311 to 3,5642; its hardness is such that it scratches quartz, and is itself scratched by the ruby; its double refraction; its electricity, vitreous on the one side,

fide, and refinous on the other, excitable by heat in those called Brazilian and Siberian topazes; its undulated and vitreous brilliant fracture longitudinally; its primitive form, the same with that of its integrant molecule, consisting in a right prism with rhombic bases, the great angle of which is $124^{\circ} 22'$, and in which the sections, parallel to the bases, are alone clear and very sensible. It is infusible by the blow-pipe; it becomes red or colourless when heated in a crucible.

According to the last analysis of the Saxon topaz, made by Citizen Vauquelin, it contains much alumine, and a little less than half as much of filix.

The varieties, which Citizen Haüy has described, are eight in number, according to its form; namely, the *amphioctahedral* topaz, having eight vertical faces between two pyramids with four faces; the *cuneiform*, having a summit in the form of a wedge; the *monostic* with one terminal face perpendicular to its axis; the *duodenary*, presenting twelve faces on the contour of its prism; the *distic*, presenting two rows of oblique facets; the *dissimilar*, in which the inferior row of oblique facets has four more in number than the superior; the *cylindroid* having a prism deformed by roundings and longitudinal grooves; the *rounded* worn by water.

He announces ten varieties by the colours; the *clear* topaz of Siberia; the *yellow* topaz of Saxony and of the Brazils; the *saffron-yellow* topaz

topaz of India; the *reddish-yellow* topaz rubicel or rubacel; the *greenish-yellow* topaz, the chrysolite of Saxony; the *greenish-blue* topaz, the aqua marine of Daubenton, of Briffon, the *Brazilian sapphire* of de Lisle; the *red* topaz, the Brazilian ruby, or balais ruby of the lapidaries; the *milky* topaz.

Lastly, the same naturalist admits three other varieties founded on the transparency, namely, the transparent topaz, the semi-transparent and the opaque topaz; which, in all, form twenty-one varieties.

The beautiful varieties of this stone are used in jewellery; but they are never of any great price in commerce. It appears that the topazes of Brazil, heated till they become red, are frequently sold and used under the name of rubies of Brazil.

17. The *emerald*: the beautiful green colour of the emerald which has been given, for a long time, as an essential character of that stone, and its lively effect, have caused it to be regarded, in all times, as one of the most magnificent productions of nature. Its physical characters are a specific gravity from 2,7227 to 2,7755; hardness sufficient to scratch quartz, though it may be scratched by the telestias; a double refraction which ceases to take place when one of the faces of the refringent angle is perpendicular to the axis of the crystals; a very sensible electric property by rubbing. Its geometric characters are the primitive form of the regular hexahedral prism,

prism, and an equilateral triangular prism for the integrant particle. Lastly, its chemical characters are a perfect unalterability in a moderate heat, or a change to a bluish tinge in a stronger fire, fusibility by the blow-pipe into an opaque grey or whitish glass, in which greenish or bluish points frequently remain.

The number of its varieties is very considerable. Five principal ones are deduced from the form; namely, the *primitive* emerald, or hexahedral prism, which also varies by the regular, irregular, and alternate inequality of its six sides; the *peridodecahedral* emerald, formed of twelve equal or unequal faces; the *blunted* emerald, the *rhombeolar*, and the *symetric* emeralds, the edges and angles of which appear to be truncated, or are replaced by facets differently configured and arranged.

The colour affords seven principal varieties of this stone; namely, the perfect green, the deep green, the blue-green, the yellow-green, the pale green, or beril, or aqua marine, the white-green, and the white. Citizen Bournon has found, in the mountains of Forez, an emerald, green in the middle and white at its two extremities; and Citizen Dolomieu has found one altogether white in the granite of the island of Elba. Lastly, the transparency affords three varieties in the emerald, the transparent, the semi-transparent, and the opaque. It is very seldom that an emerald, of considerable size, possesses a beautiful transparency; most frequently

frequently the emerald is cloudy, full of stains, or entirely opaque.

This stone has been very abundant in Peru, whence have come almost all those which are met with in commerce, under the name of emeralds of the old rock; no more of them are to be found at present, and even these first mines are no longer known. They have been found in France, in the mountains of the ci-devant Forez, Charolais, and Burgundy, and in the island of Elba. That which is named emerald of Brazil, is a tourmaline. The ancients procured them from Egypt, Scythia, and Bactriana.

The emerald and the beril contain about two thirds of their weight of silica, and one eighth of alumina. It was in the first of these stones that Citizen Vauquelin discovered his new metal, chrome, in the state of green oxide, and in both of them a new species of earth, glucine, forming nearly one fifth of their weight. Bergmann, M. Klaproth, and Bindheim confounded it with alumina.

The emerald is much in use as a jewel; it produces a very fine effect, and when it is completely transparent, and well coloured, of a grass green, it affords a great price. Some ancient physicians have attributed to it virtues almost miraculous.

18. The *euclase*: this name, which signifies *easily broken*, has been given by Citizen Haüy to a new stone brought from Peru by Dombey; it was at first confounded with the emerald on account

account of its greenish tint and its country, but it differs from it in many of its properties. Its specific gravity is 3,0625. It has a very marked double refraction. Though sufficiently hard to scratch glass easily, and quartz slightly, it does not give sparks with the steel, but is broken by the shock. Its crystals are easily divided in the direction of four planes parallel to their axis and perpendicular to each other. Two of these divisions are neat and easily obtained; the other two are rugged and difficult to be obtained.

The primitive form of the euclase is a right rectangular prism; that of its integrant particle is the same. A variety of this stone presents sixty-six faces, ten parallel to the axis, and twenty eight at each summit.

The euclase has not yet been analysed: we only know that it is fusible, by the blow-pipe, into a species of white enamel. It is of no use, because it has not yet been sufficiently abundant to be employed.

19. The *garnet*: this stone was long considered as one of the most common gems, is also one of those which has been most examined, and is best known. Its specific gravity is from 3,6511, to 4,1888. It is hard enough to scratch quartz; its refraction is simple; its fracture undulated and brilliant; its primitive form is the rhomboidal dodecahedron; that of its integrant particle, the tetrahedron with equal and similar isocetes triangular faces.

Five principal varieties are known in its form; namely, the *primitive*, or the dodecahedral garnet, with rhombic planes; the *trapezoidal*, or the garnet with twenty-four faces, and the *intermediary* variety of the preceding; the garnet in a lamellated *mass*, and the *shapeless* garnet, the pyramids of which are not terminated; three other varieties with relation to the colour, the red garnet, the green garnet, and the black garnet; finally, three with relation to the passage of the light between its laminæ, the transparent, the semi-transparent, and the opaque.

Several chemists have analyzed the garnet: according to M. Klaproth, it contains $\frac{2}{7}$ of silice, a little more than $\frac{1}{4}$ of alumine, $\frac{1}{10}$ of magnesia, a little more than $\frac{1}{6}$ of oxide of iron, and a little lime, and oxide of manganese. It is one of the hard stones that are the most fusible and the most easily attacked by the acids.

The garnet is much employed as an ornament, though it is one of the stones last in estimation, and of the lowest value.

20. The *Leucite*: this is the name which Mr. Werner has given to a crystallized stone, which has some analogy in its form with the garnet, and which had been termed *white garnet*. As it is frequently found in volcanic products, it has been imagined that it proceeded from garnets naturally heated; but this opinion has been found to be erroneous; besides which, the leucite is found in non-volcanic substances,
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and even in primitive mountains; it is frequently met with in substances which the subterraneous fire ought to have altered, and which, nevertheless, have undergone no alteration. The characters of the leucite have a specific weight of 2,4634; a middling hardness which does not scratch glass unless with difficulty, a rough fracture sometimes slightly undulated; a white or grey colour, with a slight yellow tinge, combined with a semi-transparency which is but seldom observed in it; the primitive form of a cube subdivided diagonally according to planes passing through the edges and through the centre,—a form which is the same as that of the integrant molecule.

There are some varieties of form, of colour, and of consistence in the leucite. Its most ordinary figure is a polyhedron, terminated by twenty-four equal and similar trapezoids, perfectly resembling that of the trapezoidal garnet. We meet with some specimens that are lamellated, and mis-shaped; some are semi-transparent, opaque, hard, friable, whitish, grey, greenish, yellowish, spotted; some are smooth, others granulated, and, as it were, farinaceous. The leucite is most frequently inclosed in lavas.

It is in this stone that M. Klaproth has found pot-ash united in the proportion of one fifth with more than double its weight of silicx, and with a little more than its weight of alumine. Citizen Vauquelin has since confirmed this interesting discovery, and extended it to the lava which
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most commonly contains the crystals of leucite, as well as to the earths which afford alum by the mere evaporation of their lixivium without addition.

21. The *idocrase*: Citizen Haüy has given this name to the stone which had been termed the hyacinth of volcanos, or hyacinthine, and which is very different from the true hyacinth. This denomination, which signifies a mixed form, is derived from the circumstance that its crystals partake of the forms of several other known minerals.

It is characterized by a specific gravity between 3,390 and 3,409, by a hardness which scratches glass, a double refraction, a slightly shining rough fracture, which is sometimes a little undulated. Its primitive form is the cube divisible in the direction of the diagonals of two opposite faces; that of its integrant molecule is a triangular prism with rectangular isosceles bases.

The varieties of form, in general, are referrible to the prism of eight sides, terminated by pyramids with four faces, truncated, as it were, more or less near to their bases, the edges of which are more or less replaced by facets: the principal of these varieties are five in number, amongst which there is one that has been termed *nonagesime* by Citizen Haüy, and which, presenting ninety faces, appears to present the *maximum* of the secondary forms that have hitherto been exhibited. These varieties of form are,
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moreover, distinguished by a brown, yellow, or green colour.

Though the idocrase is met with amongst the substances ejected by volcanos, it belongs to the ground itself that has been torn up by the subterraneous fires, and is not, as has been erroneously imagined, the product of those fires. Accordingly it has only been found amongst the first ejections of the volcanos, especially at Vesuvius.

It is fused by the blow-pipe into a yellowish glass. It has not yet been analyzed.

22. *Feldt-spar* : this is one of the most frequent stones in nature. It constitutes a part of the granites. Its specific gravity is between 2,4378 and 2,7045. Its hardness is such that it easily scratches glass, and emits sparks with the steel, on which account it has been termed *scintillating spar*. It has been termed *spar*, on account of its lamellated and variegated fracture. The transparent pieces have a double refraction. It is difficult to render it electric by friction, even when it is very transparent. Two pieces rubbed against each other, emit a sensible phosphoric light. Its primitive form, as well as that of its integrant molecule is an irregular oblique angled parallelopipedon.

The intimate nature of this stone is not yet well known. According to the analysis made of it by Messrs. Scopoli, Westrumb, Morell, Fabroni, and Meyer, silica constitutes the greatest part of its composition; its proportion has been indicated

indicated at between 0,55 and 0,74. The alumine is the next most abundant principle; it is said to be contained in it in the proportion of 0,17 to 0,36. Four of the above mentioned chemists have found magnesia from 0,04 to 0,06; and one of them has found lime from 0,01 to 0,06. Iron also exists in it, and appears to be its most variable element. Three of the chemists, who have analyzed it, assert, that it contains barites. Citizen Vauquelin has found pot-ash in it. It is known that feldt-spar is fusible into a species of white enamel, and that the fixed alkalis remarkably accelerate its fusion.

Its secondary form exhibits six varieties: the *rhomboidal*, the *similar*, the *apophanous*, the *polynomous*, the *semi-inverse*, and the *aggregated* feldt-spar. Besides these are distinguished the transparent, formerly called *white schorl*, and *adularia*; the unformed; the pearly, or *fish's eye*; the chatoyant, or *cat's eye*; the *opaline* or Labrador-stone. The feldt-spar is the *petunzté* of the Chinese; its great use is to serve as a flux for porcelain; and it is very evident that this property depends upon the presence of pot-ash, so that porcelain is a species of vitrification.

23. *Petrofilar*: this name which was formerly used to denote a stone which seemed to be intermediate between the pebbles, and that which was improperly termed calcareous stone, is retained to denote a substance very distinct from all the other fossils in its texture, its grain,

its aspect, &c. Citizen Daubenton characterizes the petrofilex by a semi-transparency resembling that of wax, and its scaly fracture. Its specific gravity is between 2,6527 and 2,7467. It emits sparks by the steel; it never has a lamellated texture, but one that is slightly granulated, or, as it were, conchoidal. Analogous to filex in its appearance, it differs chiefly in its fusibility before the blow-pipe. It never assumes the crystalline form, nor becomes transparent. Its principal varieties are the *common petrofilex*, the *earthy*, the *resiniform*, or *pechstein*, the *jadien* or *jade* of Saussure. M. Kirwan has found, by analysis, that petrofilex is composed of a large proportion of filex, alumine to the amount of a third of the former, and very little lime.

Citizen Haüy seems to consider this stone rather as a homogeneous substance sufficiently distinct from the other stones, as in the extract of his *Treatise of Mineralogy*, he expresses himself in the following manner: "Modern naturalists give the name of petrofilex to a substance in which feldt-spar forms the predominant part, and which is mixed with the other component principles of granite in such a manner, that its grains are indiscernible to the eye." Thus he appears to have considered it as a very fine granite.

24. The *corindon*: this is the name given in China to a stone which was formerly termed very improperly *adamantine spar*, since it is
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very far from possessing the hardness of the diamond, which was at first attributed to it. Its specific weight is 3,8732. It scratches glass very strongly, and quartz sensibly. It has a double refraction. Its primitive form is a rhomboid a little pointed; it is obtained in very neat sections. The form of its integrant molecule is the same.

Three very distinct varieties of this stone are known; the *prismatic* corindon, or in a regular hexahedral prism; the *ternary* corindon, the faces of which have alternately three, six, and nine sides; the *sub-pyramidal* corindon, or having incipient pyramids.

The name of *sterotome* has been proposed for this stone, on account of its property of cutting many hard bodies, and of the use which is made of it.

M. Klaproth, who had at first imagined he had discovered a new and particular earth in this stone, an earth which had already been admitted upon his authority under the name of corindonian earth, has since found it to be a compound of a large quantity of alumine, with a little flint, and iron.

25. The *Ceylonite*: this stone has been confounded with the tourmalines of Ceylon, amongst which it is found, or with the schorls, and the garnets. Its specific weight is from 3,7647 to 3,7931. It is sufficiently hard to scratch glass strongly, and quartz moderately. Its colour appears like a deep black, but its small fragments

are semi-transparent, and of a dark-blue colour. Its fracture is vitreous and undulated; its primitive form is the regular octahedron, and that of its integrant molecule the regular tetrahedron. One of its most frequent varieties is the octahedron, the edges of which are intercepted by facets; this is the bordered Ceylonite. Citizen Collet Descotils has found, by analysis, that it contains 0,68 of alumine, 0,16 of oxide of iron, 0,12 of magnesia, and 0,02 of silica. It has hitherto been met with only in crystals of a deep black colour.

26. The *axinite*: this term, which implies the being shaped into an edge like the head of an axe, has been given by Citizen Haüy to a stone which had been confounded with the schorls, and called the *violet*, or the *green* schorl of Dauphiny. Its specific gravity is between 3,2133 and 3,2956; it is sufficiently hard to scratch glass; its refraction is simple. It is difficult to determine its primitive form, on account of the want of continuity of the natural joints; it is a straight prism, the bases of which are obliquangular parallelograms, and which is subdivided into two triangular prisms, which represent the integrant molecules.

There are few varieties of this stone; the *lenticular*, the *inflected*, the *violet*, and the *green*, are particularly to be distinguished. The last-mentioned owes its colour to an admixture of chlorite; its form is the most regular and the neatest.

Mr. Klaproth has found in the axinite, half its weight of silex, a fourth of alumine, a tenth of lime, and another tenth of the oxides of iron and manganese. The latter metal affords the violet colour. This stone is fused by the blow-pipe into a semi-transparent glass, of a greenish-white colour.

27. The *tourmaline*: the stone definitively termed tourmaline, comprehends varieties which, at different periods, have been considered as schorls, emeralds, peridots, sapphires. These errors will, in future, be avoided, by combining all the characters that belong to this species.

Its specific gravity is between 3,0863 and 3,3636; it is hard enough to scratch glass; its refraction is simple. It is rendered electric by heat; but in a contrary manner at the two extremities of its crystals which have different faces, according to the discovery made by Epinus in 1756. It is not found to be transparent except when viewed across the thickness of a crystal; it always appears opaque, when the visual axis is parallel with that of this crystal. Its fracture is generally undulated, and brilliant, frequently articulated.

Its primitive form is an obtuse rhomboid, of which the plane angle at the summit is about $113\frac{1}{2}$ degrees, and which is subdivided into six tetrahedrons. Its integrant molecule is an irregular tetrahedron.

In all the secondary crystalline forms, whatever they may be, one of the summits constantly differs from the other in the number of its facets, so that we may know, before-hand, which of the two summits will exhibit the phenomena of the vitreous, and which of the resinous electricity. Citizen Haüy distinguishes the following six principal varieties, according to the form of the crystals ; the *very obtuse* tourmaline, the *isogonous* tourmaline, the *homologous* tourmaline, the *unequal* tourmaline, the *super-compounded* tourmaline, the *cylindroid* tourmaline. This stone differs also in its colours ; which are black, green, brown, yellowish-green and blue.

Bergmann found, by analysis, that it contains more than half its weight of alumine, a third of silice, a tenth of lime, and a very small quantity of iron. It fuses before the blow-pipe into a white or grey enamel. These stones are brought from Madagascar, Ceylon, Brazil, Tyrol, and Spain.

28. The *amphibole* : the amphibole has long been confounded with the tourmaline by such fallacious analogies, that they have suggested to Citizen Haüy the name which he has given it. It has been termed *opaque schorl*, *hornbende*, *lamellated schorl* ; it is the substance most generally designated as schorl. Its specific gravity is 3,25. It scratches glass ; its fracture is rough. Its primitive form, as well as that of its integrant molecule, is an oblique prism with rhombic

bic bases, the sides of which are inclined towards each other at an angle of about $124\frac{1}{2}$ degrees. The sections parallel with these sides are very neat. It is less hard than the tourmaline; it does not become electric like this stone by the action of heat; it affords a black glass before the blow-pipe. Three principal varieties are distinguished with respect to form; *dodecahedral*, the *biform*, and the *super-compounded* amphibole. Some specimens are black and others green.

Mr. Kirwan has found it to contain more than a third of silica, than a fourth of alumina, nearly a fourth of iron, and almost a fifth of magnesia. M. Heyer has found the same substances in it, but in proportions considerably different with respect to the silica, which he has indicated as much more abundant.

29. The *actinote*. This is a stone which Sauffure has termed *rayonante*, of which the new name is the exact synonyme: it has been confounded with schorl under the name of green schorl; its specific gravity is 3,3333. It is hard enough to scratch glass; its fracture is somewhat undulated and shining. Its primitive form is a prism with rhombuses for its bases, the planes of which are inclined towards each other at about $124\frac{1}{2}$ degrees. Its integrant molecule has the same form, which is that of the amphibole. Its most frequent variety is an oblong hexahedral prism of a grey colour. It fuses into a yellowish grey enamel, in which it dif-

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fers from the amphibole, which it so nearly resembles in its form, that it will not be possible exactly to determine the difference unless we should obtain crystals terminated by summits with facets. Hitherto we have only such as are fractured. It has not yet been analyzed.

30. The *pyroxene*. By this term Citizen Haüy implies the *being a stranger* to fire, and thereby announces that the substance to which he gives this name is not a volcanic product, as several mineralogists have believed. This stone was formerly termed *black schorl*, *volcanic schorl*; it is frequently found upon or in volcanic substances, but that is because it has constituted a part of the rocks that have been converted into lavas. The following are the specific characters which Citizen Haüy has found in the pyroxene. Its specific weight is 3,2265. It has little hardness, it scarcely scratches glass; its fracture is rough, its structure lamellated, but less so than that of the amphibole. Its primitive form is an oblique prism with rhombuses for its bases, the sides of which are inclined towards each other at about $92\frac{1}{4}$ degrees, and which is subdivided in the direction of the diagonals of its bases into two triangular prisms. This last-mentioned prism is the form of its integrant molecule.

The pyroxene is fused with difficulty by the blow-pipe, and only when it is in very small fragments. Bergmann says that it contains more than $\frac{3}{8}$ of its weight of silica, a fourth of alumine,

alumine, almost a sixth of iron, and a little lime and magnesia. Citizen Vauquelin has found the same substances in it, but he has extracted them in different proportions, especially the alumine in much smaller, and the magnesia in much larger quantity as well as the lime; he has also found it in a little magnesia.

There are two principal varieties of pyroxene; the one black and opaque, the other green, in smaller crystals and sometimes transparent. The latter, which had been distinguished as a peculiar species by the name of *virescite*, on account of its colour, has exactly the same form as the black, according to the observation of Citizen Haüy.

31. The *staurotide*. By this name, which signifies *cross-stone*, Citizen Haüy has distinguished the stony substance, which was formerly placed, under this denomination, amongst the schorls. It was the *cruciform schorl* of Romé de Lisle. The specific gravity of this stone, which is found in Galicia, and in France, in the province of Brittany, is 3,2861. It slightly scratches quartz. Its fracture is rough, a little shining in some crystals, dull and as it were argillaceous in others. It is most frequently opaque and of an earthy-grey colour. Its primitive form is a straight prism with rhombuses for its bases, the sides of which are inclined towards each other in $129\frac{1}{2}$ degrees, and which is subdivided into two triangular prisms; that of its integrant molecule is a straight,

straight, triangular prism. Its crystals frequently cross each other two and two together, so that their axes never form together any other angle than one of 60 or of 90 degrees.

There are five principal varieties of this stone, the *primitive* staurotide, the *hexagonal* staurotide, the staurotide like a square, the staurotide like a cross, and the staurotide *garnetite*. The last mentioned is the stone called *garnetite*, which has hitherto been ranked amongst the garnets or the schorls.

Mr. Heyer, who has made the analysis of the staurotide, has found it to contain nearly half its weight of silica, a little more than a fifth of barites, and a fifth of alumina. He had more than a tenth of loss.

32. The *thallite*. This term, which signifies green foliage, is given to a stone, which was hitherto confounded with the schorls, and which is found in the mountains of the province formerly called Dauphiny, and at Chamouni. This is the green schorl of Dauphiny of Romé de Lisle, and the *delphinite* of Saussure. Its distinguishing characters are a specific gravity of 3.4529, a degree of hardness that easily scratches glass, a simple refraction, a rough and somewhat shining fracture, a very great degree of brittleness in the direction perpendicular to the axis of its crystals; it yields a white powder very rough to the touch; it does not become electric by heat.

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Its primitive form is a straight prism, the bases of which are parallelograms with oblique angles, the angles being $114\frac{1}{2}$ degrees and $63\frac{1}{2}$ degrees.

Citizen Haüy mentions several interesting varieties of form which he has found in this stone. Its colour varies from the yellowish green to the dark green; its transparent pieces take a bright and shining polish.

Bergmann says he has extracted from the green schorl of Dauphiny $\frac{2}{3}$ of silice, $\frac{1}{5}$ of carbonate of magnesia, a little lime, iron and alumine. Citizen Collet Descotils has found in it a little more than a third of silice, a fourth of alumine, nearly a fifth of iron, a tenth and a half of lime, and a little oxide of magnesia. The thallite is fused with ebullition by the blow-pipe, and yields a blackish scoria.

33. The *smaragdite*. Citizen Sauffure has given this name to a stone which is very variable in its colour, most frequently green and imitating the colour of the emerald, but very far from possessing its hardness, its transparence, its regular form, and all its other properties. Sometimes it is of a beautiful shining green; sometimes it is grey, and of a metallic appearance like mica, and foliated like the same substance; it presents a succession of tinges between these two extremes. The following are the whole of its distinguishing characters. Its specific gravity is 3,0. Its hardness is slight; it scratches the crystallized earthy carbonates,
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and sometimes it slightly scratches glass. Its fracture is scaly in some pieces and rough in others. Without ever possessing the form of regular crystals, its laminae are easily divided in two different directions by sections, of which the one is plane and considerably neat, and the other dull and scarcely perceptible.

Citizen Vauquelin, who has lately analyzed it, has found it to contain half its weight of flint, a little more than a tenth of lime, as much alumina, a twentieth of magnesia, and 0,15 of the three oxides of iron, of copper, and of chrome; the last is the most abundant; next the iron, and, lastly, the copper, which does not amount to 0,02. He had nearly 0,06 of loss.

34. The *Oisanite*. This stone, which receives its name from the town of Oisan, in Dauphiny, near which it is found, has been considered as a schorl. This name, however, is not more appropriate than all those which are borrowed from places; for the stone which bears it has already been found in Spain.

The characters of the *Oisanite* are a specific gravity of 3,8571; a hardness capable of scratching glass with ease; an extremely sensible electric force of communication; and the primitive form an oblong rectangular octahedron. This form, which is the most common, subdivides itself very nearly parallel with the eight faces of the octahedron, and parallel to the common base of the two pyramids which compose the crystal by their union. We are led, by reason-

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ing, to adopt as the form of its integrant molecules the irregular tetrahedron.

The Oisanite is not fusible by the blow-pipe. It has not yet been analyzed. There are several varieties of it, especially with respect to colour. Amongst these are distinguished, the blue, or *blue schorl* of Dauphiny, the black, or *black schorl* of Oisan, and the yellow, or that of Spain. The crystals are frequently so small, that it is difficult to ascertain their form.

35. The *diopase*. Citizen Haüy has given this new name to a stone, in which we may perceive across its laminæ the juncture which unites them, by very lively undulating colours. It had been confounded with the emerald on account of its colour; but it differs greatly from it in its specific gravity, which is 3,5000, in its hardness, which is so slight that it does not scratch glass without difficulty, in its primitive form, easily obtained by dissection, which is an obtuse rhomboid, in which the plane angle, at the top, is 111 degrees, and in the form of its integrant molecules, which is the same.

The only crystals of this stone, the native country of which is not known, are dodecahedrons with six vertical parallelogrammatic obliquangular sides, with summits of three obtuse rhombuses.

Citizen Lelievre found that it imparted to borax a green colour, and that it yielded a small button of copper, by the blow-pipe. Ci-
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tizen Vauquelin's first assays might lead us to suspect that the diopase is an ore of copper.

36. The *lazulite* : this was formerly termed, *lapis, lapis lazuli, Armenian stone*. Its name is derived from *azul*, which is the appellation that was given by the Arabs to this stone. It is very easily recognised by its beautiful blue colour, its specific gravity between 2,7675 and 2,9454; its hardness, which is such that it scratches glass, and emits sparks at some points, its granulated, fine, and close fracture, and the total absence of the crystalline form. It varies in the richness of its blue colour; frequently it is mixed with feldt-spar and sulphuret of iron. Margraff found it to contain silica, lime, sulphate of lime, and iron. M. Klaproth has found it to contain more than a tenth of its weight of alumine. It yields sulphurated hydrogen gas with the acids.

This is the stone with which the ultra-marine blue is prepared, the most beautiful, and most durable of all the pigments employed in painting. It would be one of the finest discoveries in chemistry, were it possible to imitate this precious colour by art, as Nature presents it but seldom, in little abundance, and frequently impure.

37. The *zeolite* : Cronstedt has given this name to a stone which boils in the fire as it fuses. This appellation of the celebrated Swedish mineralogist is retained to distinguish the species in the French lithology.

The following are the characters whereby this species, with which several other stones, more or less different from it, have been confounded, is sufficiently distinguished. Its specific gravity is equal to 2,08333; its hardness is slight, and only acts upon the carbonate of lime. It becomes electric by heat like the tourmaline; the vitreous or positive electricity occupies the projecting pyramids, and the resinous, or negative electricity resides towards their adhering base. Its fracture is a little undulated; its primitive form is a straight prism with square bases, that of its integrant molecules is the same. It has also the property of easily forming a jelly with the acids. Its form, its electric quality by heat alone, and its gelatinous nature in its acid solutions, particularly distinguish this species of stone from the different compounds with which it has been so gratuitously associated in different systems of lithology.

Amongst the principal varieties of the zeolite, we ought to distinguish that of Cronstedt, in long quadrangular prisms, terminated by pyramids with four depressed faces. There are, also, differences of colour which may form varieties, or subordinate varieties in the zeolite.

This stone has been analyzed by Bergmann, Pelletier, Meyer, and Klaproth. All these chemists have found silica as the most abundant principle from 0,44 to 0,60; alumina in the second proportion from 0,18 to 0,30; lime in the third, from 0,03 to 0,18; water from 0,04

0,04 to 0,22. M. Klaproth has also announced that it contains a small quantity of iron. The property which the zeolite possesses of boiling whilst it fuses, is manifestly owing to the water which it retains.

38. The *stilbite* : a stony substance, of a shining appearance resembling mother-of-pearl, as its name expresses. It is the second species of zeolite, which Citizen Haüy distinguished some years ago, and of which he has since made this particular stone, after having studied it with greater attention. In fact, it has very distinct characters; especially a weight of 2,5 ; a greater degree of hardness than the zeolite, properly so called, as it easily scratches it ; a lustre resembling that of mother-of-pearl ; the primitive form of a straight prism with rectangular bases ; but the sections, parallel with the straight faces, are alone neat. Its integrant molecules are of the same form. It has two principal varieties of crystals, the one, in dodecahedrons with four hexagonal faces, with summits of four obliquangular parallelograms ; the others, in hexahedral prisms, the four solid angles of which, are replaced by triangular facets with a different height.

The stilbite when placed upon burning charcoal, loses its transparency, decrepitates, and becomes friable like crystallized sulphate of lime. It swells, fuses, and is reduced into a white enamel, semi-transparent, and filled with bubbles like the zeolite. Citizen Vauquelin found,

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by analysis, that it contained more than half its weight of silica, almost a fifth of alumine, almost a tenth of lime, and nearly a fifth of water. Hence we see that it approaches very near to the zeolite in its nature.

39. The *Prehnite*, a name formed from that of Colonel Prehn, who brought this stone from the Cape of Good Hope. It has also been found in France. That of the Cape has a specific gravity equal to 2,6969; that of France, to 2,6097; it is sufficiently hard to scratch glass slightly. It is a little pearly, in greenish crystals, confusedly grouped together, divergent, in tetrahedral prisms with dihedral summits. That of France, which is found in Dauphiny, is in rhomboidal laminæ, with lateral faces inclined towards each other, at angles of 101 and 89 degrees; or in hexagonal laminæ, having two angles of 101 degrees, and four of $129\frac{1}{2}$ degrees; or in laminæ grouped together, and divergent like the sticks of a fan—this is termed the *flabelliform* prehnite; or, lastly, in bundles of curvilinear divergent laminæ; this is the *conchoid* prehnite. It is white or green. Its primitive form, as well as that of its integrant molecules, is a straight rhomboidal prism, with bases whose angles are about 101 and 79 degrees.

The prehnite is fused by the action of the blow-pipe into a white porous froth, which becomes an enamel of a blackish yellow colour. M. Klaproth has found it to contain nearly half its weight of silica, nearly a third of alumine,

nearly a fifth of lime, 0,05 of iron, and a little water. The analysis made by Citizen Hassenfratz gave him results perfectly corresponding with these. It is evident, that this stone differs from the zeolite merely by its containing much less water; accordingly it does not boil, like the latter, previous to its fusion.

40. The *chabasite*; this is an ancient and Homeric name of a stone, which has been revived some years ago, and applied to a stony compound, which was first considered as constituting a variety of zeolite, termed the *cubic*, but which Citizen Haüy, by appropriating to it this distinct appellation, has separated as a peculiar species. It is found in Germany, near Oberstein. Its specific gravity is 2,1176; it scarcely scratches glass, and feldt-spar but slightly; its structure is lamellated. Its primitive form is a rhomboid slightly obtuse, the plane angle at the summit of which is about $93\frac{1}{2}$ degrees; its integrant molecules have the same form.

It has two varieties of form: the one which is the primitive, and the other which is termed the *tri-rhomboidal*, because, by presenting a rhomboid incomplete in the three edges of each summit, and in the six solid lateral angles it gives the idea, if we suppose the facets to be continued till they intersect each other, of two different rhomboids, which, united with the primitive, present three possible rhomboids. This species of stone has not yet been analysed:

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the attention of lithologists was first directed to its distinctions, some years ago, by Citizen Bosc d'Antic.

41. The *analcime*: Citizen Haüy has given this name, which signifies *without strength*, to a stone which is very difficult to be rendered electric by friction, and which he had at first considered, with several other naturalists, as a variety of zeolite. It was termed *hard zeolite*, *granatic zeolite*. Its specific gravity is nearly equal to 2. It scratches glass slightly. Its fracture is undulated in the transparent pieces; compact, and very fine-grained in the opaque crystals. The most transparent of the crystals become but very slightly electric by friction. Its primitive form, as well as that of its integrant molecules, is the cube.

Sometimes in the secondary forms, each solid angle of the cube is replaced by three triangular facets; sometimes it presents a polyhedron resembling the garnet with twenty-four trapezoidal facets. The one is the *cubo-pyramidal analcime*; the first was formerly the *cubic zeolite*, or the zeolite with thirty facets; the second, the *granatic zeolite*. It is found transparent, opaque, white, and flesh-coloured.

The analcime is fused by the action of the blow-pipe, without swelling, into a semi-transparent glass. It is found in grouped crystals, deposited by water in the fissures of hard lavas. It is manifestly posterior to their formation, whilst the leucite has preceded it, and has

been enveloped by them. No accurate analysis has yet been made of the analcime.

42. The *Sommeite*: this stone had been considered as an hyacinth, and termed the white hyacinth of La Somma, a name of the mountain Vesuvius upon which it is found. Born termed it *white basaltes*, and Ferber *white hexagonal schorl*. It is a distinct species of stony compound, characterized by the following properties. Its specific weight is 3,2741; it is sufficiently hard to scratch glass with its pointed parts; its fracture is rough, approaching to the vitreous, as viewed through a magnifying glass. The primitive form which it pretty constantly affects, is that of a regular hexahedral prism. That of its integrant molecule is the equilateral triangular prism. It is difficult to be fused by the blow-pipe: it contains nearly equal parts of flex and alumine, but very little lime, and oxide of iron, according to the analysis of Citizen Vauquelin. It is evidently very different in its nature from the hyacinth.

43. The *andreolite*: this name, taken from Andeasberg in Saxony, from whence this natural compound comes, is given to a stone which Romé de Lisle had termed the *cruciform white hyacinth*, and which Bergmann had likewise ranked amongst the hyacinths. Its weight is 2,3. It slightly scratches glass: its fracture is rough. Its powder, thrown upon burning charcoal, emits a phosphoric light of a greenish-yellow colour. Its primitive form is a rectangular

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gular octahedron, which is subdivided in a direction parallel with planes, passing through the edges contiguous to the summits, and through the centre. Its integrant molecule is an irregular tetrahedron. It is generally a macle composed of two flattened tetrahedral prisms, terminated by two tetrahedral pyramids, and intersecting each other at a right angle, in consequence of which it has been termed *cruciform*. Messrs. Heyer and Klaproth have found it to contain filix, alumine, and barites; the first constitutes nearly half of it, the two others about a fifth each. According to M. Klaproth, it contains 0,15 of water.

44. The *peridot*: at present, the name of peridot is given to certain stones far less numerous than those which have long been confounded together under this denomination, and which several mineralogists have not even known. The physical characters of the real peridot are a specific gravity equal to 3,4285, a hardness capable of scratching glass, a very strong double refraction, an undulated and brilliant fracture: the natural joinings of its laminae are in a direction parallel to its axis.

Its primitive form is that of a straight prism, with rectangular bases; that of its integrant molecule is the same. There are some remarkable varieties of this stone, especially those which are termed the *peridot micronome*, the *peridot duodenaire*, &c. Its ordinary colour is a greenish-yellow. Amongst these varieties, we must also

also class the pretended volcanic chrysolite, or the *olivine* of Werner, so named on account of its colour.

Citizen Vauquelin has analyzed the peridot, and has found it to contain more than half its weight of magnesia, a little more than two thirds of silica, and about a tenth of oxide of iron; he had not more than $\frac{2}{100}$ loss. He has observed that this stone was not fused, either alone, or with the phosphate of soda, by the action of the blow-pipe, and that with borax it yielded, without effervescence, a transparent glass of a slightly green colour.

45. *Mica*: this is one of the stones most easy to be distinguished by its brilliancy, which frequently imitates the metallic lustre, by its elasticity, by its softness, by its being greasy to the touch, without having an unctuous aspect; its specific gravity is between 2,6548 and 2,9342. It is easily scratched; it rather tears than breaks. Its primitive form is a right prism, with rhombuses for its bases, the angles of which are 120° and 60° . The divisions made parallel with the bases are very clean; those made in the lateral direction are dull and tarnished. Its integral molecule is of the same form.

Amongst the varieties of form in this stone, are distinguished, the *primitive* mica, or in a short rhomboidal prism; the *hexagonal* mica in a hexahedral prism, or in hexagonal laminae; the *rectangular* mica; the *foliated* mica, talc, or Muscovy glass; *lamelliform* mica; the *hemispheric*

mispheric mica; the *filamentous* mica: the *pulverulent* mica. With respect to colour, there is *gold-coloured* mica; *silver-coloured* mica; *greenish*, *reddish*, *yellowish*, *brown*, and *black* mica; *transparent*, *semi-transparent*, and *opaque* mica.

Mica is a primitive stone, mixed with quartz, and feldt-spar; it is frequently carried into the secondary earths; it is one of the natural substances that reflect light the strongest.

Mica is fusible by the action of the blow-pipe into a white, grey, greenish, or blackish enamel. By an accurate analysis, Citizen Vauquelin found it to contain half its weight of silice, a third of alumine, more than a twentieth of oxide of iron, and very little lime, and magnesia.

It is much used for windows, and especially those of ships, instead of glass, in the construction of lanterns, in ornamental works, for drying writing, &c. When employed for the last mentioned purpose, it is improperly termed, gold or silver powder, cat's silver, &c.

46. The *cyanite*: this stone, which has been named *blue schorl*, and *sapphire*, has a specific gravity of 3,5170. It does not scratch glass, unless we rub the glass with a very sharp point of the stone. It possesses only simple refraction. Its primitive form is an oblique quadrangular prism, the faces of which are inclined towards each other in an angle of about 103 degrees; its

its integrant molecule has the same form. In the crystals of this stone there are always divisions parallel to two opposite faces, which are much neater than those which answer to the other faces.

Amongst the varieties of its form, one of the most remarkable is that of hexahedral prisms which are applied two and two together so as to present a concave angle on one side, and a projecting angle on the other. They are found on mount St. Gothard.

Sauffure and M. Struve, in their analyses of this stone, have obtained very different results. According to the first, the silic and magnesia form each an eighth part of its weight, the alumine more than two thirds, and the iron a twentieth. Mr. Struve, on the contrary, asserts, that it contains one half silic, one third of alumine, one twentieth of magnesia, and as much lime and iron.

47. The *Tremolite* : or the stone of mount Tremola, is well characterized by its specific gravity between 2,9 and 3,2, its hardness which scratches glass, its undulated fracture, the coarseness, and hardness of its powder, which tears and irritates the skin when rubbed upon it, the reddish-white phosphorescence which it exhibits when struck in the dark; finally, by its primitive form, which presents an oblique quadrangular prism, whose faces form angles of about twenty-seven degrees. The sections, parallel to its faces, are very neat. The form
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of its integrant molecules is the same. There are several varieties of it in the crystalline form, one of which is fibrous. This stone is hitherto little known. According to M. Klaproth, it contains more than two-thirds of its weight of flint, nearly one fifth of lime, one tenth of magnesia, one twentieth of water, and carbonic acid.

48. The *leucolite* : this name, which simply signifies white stone, has been given to a species that has been ranked amongst the schorls. It was Romé de Lisle's *white prismatic schorl* of Attenberg in Saxony. Its specific gravity is 3,5145. It slightly scratches quartz. Its fracture, which is dull, appears by its inequalities to be rather scaly. Its primitive form, which as yet is only conjectured, appears to be the regular hexahedral prism, and that of its integrant molecule an equilateral triangular prism. Mr. Wiegand has found it to contain equal parts of flint and alumina. It does not fuse before the blow-pipe.

49. The *dipyre* : this is the name given by Citizen Haüy to a stone, that was found in 1786, by Citizens Lelievre and Gillet, near Manléon. It consists of bundles of minute prisms that have a faint lilach colour. Its specific gravity is 2,6305. It scratches glass ; its fracture is undulated and brilliant, its powder thrown upon an ignited coal appears slightly luminous in the dark. Like the leucolite, its primitive form is the regular hexahedral prism, and

and that of its integrant molecule the equilateral triangular prism. It ought, however, not to be confounded with the former, as it is very fusible before the blow-pipe, and differs from it in its composition. Citizen Vauquelin has found it to contain much flint, alumine, a little lime, and oxide of manganese as a colouring principle.

50. *Asbestos* : the name of asbestos, which is already ancient, and which signifies *inextinguishable*, though this word has been taken for that of *incombustible*, belongs to a stone, which is most frequently of a fibrous texture resembling that of cloth, or vegetable fibres. This substance is confounded with the amianthus. This earthy compound is very variable in its specific gravity, which seems to vary from 2,7958 to 0,6806 ; this depends upon the great difference of the approximation, or separation of its fibres. It varies, likewise, very greatly in its hardness ; sometimes it is sufficiently hard to scratch glass ; in some varieties, on the contrary, it has the softness of cotton. Its powder is always soft to the touch. Its structure presents filaments sometimes flexible, sometimes brittle, united longitudinally in bundles, or interwoven so as to resemble membranes.

These differences determine the principal varieties which are distinguished in this substance ; the *flexible* asbestos ; the *hard* asbestos ; the *fibrous* asbestos, the *interwoven*, *spheriform*, *coriaceous* asbestos, &c.

Bergmann

Bergmann tells us, that he has found in this stone more than one half of filex, nearly one fifth of magnesia, little alumine, more than a tenth of sulphate of barites, and of lime. M. Wiegleb says, he has extracted from it more magnesia than filex, and several modern lithologists have ranked this stone amongst those of the magnesian class.

Formerly the variety of asbestos, called mature amianthus, was much used for preparing a sort of incombustible thread, or cloth, which was chiefly employed for wicks in sepulchral lamps, and for collecting the ashes of human bodies after combustion, &c.

51. *Talc* : Though this term has often been a synonyme of mica in mineralogy, it is adopted by the moderns, to denote a stony substance which differs from it, especially in an unctuousity sensible to the touch, and in the vitreous electricity which it communicates to sealing-wax by friction, whilst mica gives it the resinous electricity. Citizen Haüy enumerates four varieties of this stone ; namely, the *laminary* talc, or Venice talc ; the *foliated* talc, or chalk of Briançon ; *compact* talc as the lard-stone ; these three first give the positive or vitreous electricity to sealing-wax. The fourth variety, or the *steatites* talc, communicates the negative or resinous electricity to it by friction.

The characters of this stone are—a specific gravity between 3,5834 and 2,9902 ; a texture easy to be scraped with the knife, a soft and unctuous

tuous surface, the primitive form of a right rhomboidal prism, its bases having angles of 120 degrees and 60 degrees; and in which sections parallel with these bases are easily obtained. Its integrant molecule has the same form.

M. Kirwan has found in this stone, almost as much magnesia as silica, and only a twentieth part of alumine. Amongst the varieties of talc, which are sufficiently numerous, the mixed steatites, the serpentine and pot stones are not ranked.

The softness of the texture of the talcs, the fineness of their powder, their easy suspension in water, which they powerfully absorb, and the hardness which they contract by the action of a moderate heat, renders them useful in a great number of the arts, or for domestic purposes.

52. The *chlorite*: this name, which signifies a green substance, is improperly applied to a stone which is not always of this colour, and which formerly was considered to be a steatite, or talc. This stone is brilliant, like mother-of-pearl, unctuous to the touch; when solid it has a specific weight of 3,0966; it has so little hardness that it never scratches glass; it is even most frequently pliant or friable. It has no crystalline form, and only assumes that of laminae. Two varieties of it are distinguished; the one of a pearly and silver whiteness, the other of a dark green. The latter is frequently disseminated

diffeminated between the layers in the interior of the crystals of quartz.

M. Hoepfner and Citizen Vauquelin have severally analyzed the chlorite; the difference between their results is so great that we should be induced to think that they did not both examine the same stone. The former found it to contain nearly one half of magnesia, whilst the latter did not find in it more than one tenth; the one says it contains lime, which the other did not find in it; the proportions of iron, and of alumine indicated by each differ essentially. Citizen Vauquelin says, it contains 0,43 of oxide of iron, which almost gives this substance a title to be ranked amongst the ores; whilst M. Hoepfner estimates it at only a little more than one tenth. Citizen Vauquelin finds in it an alkaline muriate, and water in small quantity; M. Hoepfner mentions neither the one nor the other of these substances.

53. The *macle*. The word *macle* signifies a lozenge or rhombus, hollowed out, or concave, parallel with its sides; it here denotes a very singular stone in quadrangular prisms, the faces of which are inclined at 95 degrees and 85 degrees, presenting in their fracture indications of laminæ parallel with the faces, and others in two different directions. The transverse section of these prisms presents a blackish rhombus inserted into another of a whitish colour, with four other smaller black rhombuses situated at the angles of the whitish rhombus, and connected

nected with the central one by lines of the same colour. This appearance represents a kind of cross; sometimes the lines which form the connections between the rhombuses are ramified into other lines parallel with the sides.

The whitish part of this stone resembles the compact steatites; the black part generally diminishes in thickness from one extremity of the prism towards the other, so that having at first occupied its whole breadth, it terminates in a simple filament. Sometimes also there are only the black prisms without any white matter, and in some there is nothing more than a whitish pellicle at their surface, which is imperceptible unless when it is moistened.

The matter of the prism has a specific gravity equal to 2,9444; that which serves as a covering to it weighs only 2,7674. The macle is hard enough to scratch glass; its texture is a fine and close grain; its powder soft to the touch. It has not yet been analyzed, and its chemical properties are still unknown.

54. *Argil.* Citizen Haüy only regards that earth as clay in which alumine superabounds. He ranks the *kaolin* alone in that species. The common and coloured clays, the schisti, the horn-stones, the traps, the marles, the boles, the fuller's earths belong to the mixtures; he places them, as well as the grit-stones, the granites, the porphyries, and all the rocks in general, in the appendix to his method. The characters of the clay which we now treat of are

are very definite and very easily understood. It is opaque, earthy, friable, soft, unctuous, and as it were soapy under the finger, adhering to the tongue, forming a paste with water, infusible by heat, hardening by baking, and affording, by long maceration in sulphuric acid, an acid sulphate of alumine, which easily becomes alum by the addition of a little pot-ash or ammonia. It is of great use in making porcelain.

55. These forty-five stony substances are the types or original representation of the earthy combinations hitherto known, and form so many distinct species which should be regarded as a series of unities very detached from each other. Though all the stony productions may be referred to these combinations, it frequently happens that nature presents them in such mixtures as render it impossible any longer to discover the substance which forms its leading compound part, particularly when the mixture takes place in variable proportions. The method cannot be applied farther to these compounds, of which the primitive component parts are comprised in the first distinctions, except in the form of appendix. This is what Citizen Haüy has done with regard to all the mixed stones or rocks which the geologist must study, because they form the mass of the mountains, and of the whole globe. These mixed stones may be divided into three orders. The first belongs to the aggregates formed from the union of contemporaneous substances which

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have crystallized together in the same solution ; these are the rocks composing the primitive earths.

The second order includes the stony aggregates of more recent origin ; formed by disposition and drying, as the marles, the schisti ; they frequently include the acidiferous compounds, or the earthy salts which will be treated of in the following section.

Lastly, in the third order are arranged the aggregates formed by the re-union of the fragments of ancient stony substances connected by a cement, such as the pudding-stones, the breccias, and the grit-stones.

56. To explain, and methodically to arrange these mixed or aggregated stones, of which the nature, proportion, or respective position in the earth enable the geologist to determine the antiquity, the formation, and the revolutions of the masses, or countries which they compose, Citizen Hallé adopts a nomenclature which points out what the eye can perceive in each piece, by describing, under a generic name, the principal stony substances which predominate in the same, by sometimes adding the names of those which accompany this first principle, and another expression which announces the relative mode of existence of these materials, as *foliated*, *amygdaloid*, &c. These methodical denominations, derived from the primitive names, and much preferable to those of *granite*, *serpentine*, *porphyry*, *gneiss*, are appropriated unequivocally

cally to indicate the groups of real species which, by their aggregation, form the mixed stones. The same is the case with the volcanic products the exposition and classification of which form a second appendix in the French mineralogy.

SECTION FIFTH.

Concerning the general Processes, or the Method of Analysis employed by Modern Chemists to discover the Composition of Stones.

1. THE first operation consists in reducing the stone, which is to be analyzed, into as fine particles as possible. For this purpose it is pounded with water in a mortar of agate or which is still better, of flint. When the water becomes milky, it is poured off, and more is added, which is also poured off under the like circumstances; and this is to be repeated till nothing more remains in the mortar. All this water must be reserved in a vessel adapted to permit the stony particles to subside. When the water has become sufficiently limpid, it is drawn off clear, and the powder, which is found at the bottom of the vessel, is well dried.

One hundred parts of this powder are taken and put into a crucible of pure silver, with three times as much dry caustic pot-ash, prepared by alcohol; this is heated, and the degree of heat

is so managed that the crucible is ignited, but not fused.

After having kept the crucible for half an hour, or three quarters of an hour in the fire, it is left to cool, and when it is well cleaned on the outside, it is put into a capsule of glass, or of porcelain; which is filled with water to dilute the matter which it contains.

2. All the fused mass being diffused in a sufficient quantity of water, and placed in the capsule, some muriatic acid is thrown on it, which at first precipitates the filix, and the alumine, but by adding greater quantity redissolves these two earths, as well as those which are insoluble in the alkali, and consequently not dissolved in the water; there only remains at the bottom of the liquor those parts of the stone which were not decomposed, or dissolved by the alkali. These last must be again treated in the same manner, till the whole is dissolved in the muriatic acid.

The solution is then evaporated to dryness, a little muriatic acid is added to replace that which the alumine might have permitted to escape, and the product of this evaporation is dissolved in distilled water. After having been thus heated, the filix becomes insoluble in the acids, and remains at the bottom of the liquor; it is collected on the filter; then ignited in the silver crucible, to disengage the water which it obstinately retains, and lastly it is weighed.

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3. All the earths which have been dissolved by the muriatic acid, are afterwards precipitated by an alkaline carbonate, for example, by that which is obtained by the combustion of tartar by nitre.

After having well washed and dried the precipitate, it is treated with a slight solution of caustic pot-ash, prepared by alcohol. The alumine is dissolved, and after having separated the other pulverulent earthy substances by the filter, the alkaline solution is saturated with an acid, of which is added a quantity sufficiently great to redissolve the alumine. It is precipitated again by an alkaline carbonate, such as that which has been mentioned. The precipitate is then washed, dried by a red heat, and weighed. The portion of alumine is thus separated.

4. The other earthy substances, which were not attacked by the caustic alkali, are treated with muriatic acid. When all is dissolved, the lime, the magnesia, and the oxide of iron, are precipitated, if present, by a solution of caustic pot-ash prepared by alcohol. The precipitate is separated; the muriate of barites which may remain in the liquor, and which could not be decomposed by the pot-ash, is precipitated by sulphuric acid; this new precipitate is dried, and its weight indicates that of the barites, the proportions of the sulphate of barites being known, as will be mentioned elsewhere.

The separation of the lime and of the magnesia is very difficult, and can never be perfect.

To approach to it as much as possible, the precipitate, formed by the alkaline solution, is redissolved in muriatic acid, and this muriatic solution is evaporated to the consistence of a syrup. The lime is then precipitated by concentrated sulphuric acid ; it is proper not to wash the precipitate too much, because the fulphate of lime is soluble in five hundred times its weight of water. The washed and dried precipitate indicates the quantity of the lime.

Magnesia may be precipitated by a caustic alkali, or by an alkaline carbonate which should not be too much saturated with acid, because the magnesian carbonate would remain in solution. In the first case, pure magnesia will be obtained ; in the second, there will be a carbonate of magnesia.

5. If iron be present, which is always probable, it must be precipitated from the preceding solution before the magnesia is treated ; there are, for this purpose, two methods equally good. The iron may first be precipitated by an alkaline prussiate, a salt which will be treated of in the section upon animal matters, and the magnesia may be afterwards precipitated by an alkali, or by an alkali perfectly saturated with carbonic acid. The carbonate of iron will be precipitated ; and after being washed, dried, and weighed, the weight of the iron will easily be known. The solution is then boiled, which permits the carbonate of magnesia to precipitate in proportion

tion as the carbonic acid, which dissolves it, is disengaged.

6. Zircon has only yet been found in combination with flint, and a little oxide of iron, in the jargon and the hyacinths; the method, which has been successfully employed to separate these three substances, and to determine their relations, is the following. These stones are carefully pulverized; they are heated in a crucible of silver and of platina, with four times their weight of dry caustic pot-ash, till the whole is strongly ignited, and in clammy fusion in all its parts. The matter is diluted in a sufficient quantity of water, and it is then dissolved in muriatic acid. If the operation has been well made, there will not remain any thing undissolved. The solution is then evaporated by a gentle heat till it has taken the consistence of a soft paste; this paste is diluted with water; and, by this means, the muriate of zircon is dissolved, and the flint remains at the bottom in the form of a white, granulated powder, the weight of which is taken after it has been washed and ignited.

To have the zircon pure, the solution is evaporated again to dryness, in order, that if the muriatic acid have retained some portions of flint, it shall permit them to escape by this new evaporation. When it has deposited the flint, the matter, diluted with water, is then filtered, and the zircon is precipitated by a caustic

alkali,

alkali, and after being washed, and dried, it is weighed.

7. We have not yet any very certain and very exact means of separating zircon from the oxide of iron : that which appears least inaccurate, is strongly to ignite the combination of these two bodies, then to pulverise it very finely, and macerate for some hours in muriatic acid ; by this means, almost the whole of the iron is carried off without sensibly dissolving the zircon. But if it be afterwards desired to combine this earth with the acids, in order to form salts, it will be necessary to treat it again with three or four parts of caustic alkali in a silver crucible, and proceed as was done with the jargon or the hyacinth. If the zircon should hereafter be found combined at the same time with flint, alumine, and lime, it may always easily be separated by redissolving the alumine in caustic alkali, and afterwards precipitating the zircon by ammonia, which does not separate the lime, &c.

8. Glucine was first discovered in combination with flint, with alumine, with lime, the oxide of iron, or the oxide of chrome. The processes for fusing and separating the flint are the same as for all the other stones which contain that substance : then the alumine, glucine, and the oxide of iron, or chrome, are precipitated from the muriatic solution by the ordinary alkaline carbonate ; and, after having washed the deposition, it is dissolved in sulphuric acid ; to
this

this is added a small quantity of potash and it is evaporated. When, by a series of successive evaporations and crystallizations, the whole quantity of octahedral alum which the liquor can afford is taken away, the mother water is diluted, and a solution of carbonate of ammonia is mixed with it till it possesses an excess perceptible to the smell and the taste. By this means the glucine is entirely dissolved, and the little alumine which may yet continue mixed remains at the bottom with the oxide of iron or of chrome. The glucine is then procured by boiling its solution in the carbonate of ammonia for some time; it falls down in the form of a white, granulated powder; and is easily freed from its carbonic acid by slightly igniting it in the silver crucible. The oxide of chrome or of iron is then separated, by treating the matter, precipitated by the carbonate of ammonia, with caustic pot-ash; the alumine is dissolved, and the one or the other of these oxides remains pure.

9. When the deficiency which is found in the analysis of a stone, made by the ordinary means, gives cause to suppose that it contains pot-ash, it is necessary to treat it with the acids, after having reduced it into a very subtile powder. The sulphuric acid appears best suited for this operation, as being the most fixed and the strongest; of this acid ten or twelve times the weight of the stone is used, particularly when it is very hard. It is boiled for twelve hours
in

in a matrafs with a long neck, and ftill better in a crucible of platina; the mixture is then placed in a capfule of porcelain, where it is evaporated to perfect drynefs; the mafs is then diluted in boiling water, and it is washed till it becomes taftelefs; all the wafhings, put together, are then precipitated by ammonia. If the acid has diffolved alumine and iron, they are thrown down: the folution is then filtered and evaporated to drynefs; the refidual mafs is re-diffolved in water and filtered, if it has depofited any thing which may not be fulphate of lime. The liquor is again evaporated; and when it is reduced to drynefs, the falt which remains is ignited in a crucible of platina till it emits no more white fumes. A refidue is left in the crucible; it is fulphate of pot-afh, which is eafily diftinguifhed by characters which will foon be indicated. If foda fhould exift in fome ftoney compounds, it may be difcovered by the fame procefs, and it may be diftinguifhed by the falt very different from the preceding, which it forms with the fulphuric acid.

10. If the oxides of iron, of manganese and of chrome fhould be at any time met with combined in a ftone, they are all three feparated at once from the earths, as was before obferved, and then they are treated as follows. After heating them in a crucible, they are boiled with acetous acid; this will diffolve the manganese and the chrome; the iron will remain undiffolved; or if there be fome portion diffolved, it will be

be precipitated by evaporation. The chrome and the manganese may be precipitated by an alkaline carbonate; the precipitate is then to be heated in a close vessel, in order to oxide the manganese, and it must then be boiled with weak nitric acid. The oxide of chrome will be dissolved, but that of manganese will not.

11. The substances which have been pointed out as existing in stones, may form, as may be easily conceived, an infinite number of different combinations; but their separation will always be obtained, by attending well to the properties which characterize each of them; it would be useless to enter into any longer details in this place. In the following section, where the properties of saline substances are treated at length, many other processes are given to discover and separate each of the earthy matters, and in particular strontian which has not hitherto been treated, because it is not yet met with in compounds purely stony, but only in the acidiferous or saline combinations. We must be contented with observing here that if, by chance, one of its saline compounds should be found to form a part of a stone, particularly with another compound, analogous to the base of barites, which very frequently accompanies those of strontian, the presence, the nature, and even the proportion of this last may be determined by boiling the pulverized stony matter with three times its weight of an alkaline carbonate in solution; by treating the pulverulent residue, which
would

would contain carbonate of strontian, with muriatic acid; and the muriate of strontian, which is obtained by this treatment, being first dissolved in water, then evaporated to dryness, and then dissolved in five or six times its weight of alcohol; if this last solution, after cooling, should contain the muriate of strontian, it will burn with a purple flame, and may be precipitated by a very pure alkaline carbonate, so as to give the proportion of its earth.

SEC. VI.

T A B L E

OF THE

Analysis of Stones, made by different Chemists.

I. Quartz.

By BERGMANN.

Silex	93	Lime	1
Alumine	6		

II. Silex.

Flint of a grey black. By M. KLAPROTH.

Silex	98	Oxide of iron	0,25
Lime	0,50	Volatile parts	1
Alumine	0,25		

Opal. By M. KLAPROTH.

Silex	90	Water	10
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Calcedony of Ferro. By BERGMANN.

Silex	84	Alumine	16
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The Same. By M. BINDHEIM.

Silex	83	Alumine	2
Lime	11	Iron	2

Hydrophane.

460 COMPONENT PARTS OF STONES.

Hydrophane. By M. WIEGLEB.

Silex	83	Iron	0,5
Alumine	5	Water	5

Hydrophane. By M. KLAPROTH.

Silex	93,125	Volatile parts and	
Alumine	1,625	water	5,250

Pechstein. By M. GMELIN.

Silex	90	Iron	3
Alumine	7		

Silex. By M. WIEGLEB.

Silex	80	Lime	02
Alumine	13		

Silex. By Citizen VAUQUELIN.

Silex	97	Lofs	2
Alumine and Oxide of Iron	1		

III. Zircon.

By M. KLAPROTH.

Zircon	69	Oxide of Iron	0,50
Silex	26,50	Lofs	4

By M. WIEGLEB.

Silex	87,50	Oxide of Iron	2,50
Magnesia	3,30	Lofs	4
Lime	2,67		

Hyacinth. By M. KLAPROTH.

Zircon	70	Oxide of iron	0,50
Silex	25	Lofs	4,50

Hyacinth. By Citizen VAUQUELIN.

Zircon	64,5	Oxide of iron	2
Silex	32	Lofs	1,5

Hyacinth

Hyacinth. By BERGMANN.

Alumine	40	Oxide of iron	13
Silex	25	Loss	2
Lime	20		

Hyacinth of Expailli. By Citizen VAUQUELIN.

Zircone	66	Iron	2
Silex	31	Loss	2

IV. *Blue Telefia.*

By M. KLAPROTH.

Alumine	98,50	Lime	0,50
Oxide of iron	1		

By BERGMANN.

Silex	35	Lime	5
Alumine	58	Iron	2

V. *Cymophane.*

By M. KLAPROTH.

Alumine	71,50	Silex	1
Lime	6	Loss	3
Oxide of iron	1,50		

VI. *Ruby.*

By M. KLAPROTH.

Alumine	74,50	Oxide of iron	1,50
Silex	15,50	Lime	0,75
Magnesia	8,25		

By Citizen VAUQUELIN.

Alumine	82,47	Chromic acid	6,18
Magnesia	8,73	Loss	2,57

VII. *Topaz*

VII. *Topaz of Saxony.*

By Citizen VAUQUELIN.

Silex	31	Lofs	1
Alumine	68		

By BERGMANN.

Alumine	46	Lime	8
Silex	39	Iron	6

By M. WIEGLEB.

Alumine	44	Lime	8
Silex	52	Iron	1

VIII. *Emerald.*

By Citizen VAUQUELIN.

Silex	64,50	Oxide of chrome	4,25
Alumine	15	Lime	1,60
Glucine	14	Volatile matters	1

By BERGMANN.

Alumine	60	Lime	8
Silex	24	Iron	6

By M. KLAPROTH.

Silex	66,25	Oxide of iron	0,50
Alumine	31,25		

IX. *Beril.*

By Citizen VAUQUELIN.

Silex	69	Oxide of iron	11
Glucine	16	Lime	0,5
Alumine	13		

By M. BINDHEIM.

Silex	64	Lime	8
Alumine	27	Iron	2

X. *Euclase.*

X. *Euclase.*

It has not yet been analyzed.

XI. *Garnet.*

By M. KLAPROTH.

Silex	40	Magnesia	10
Alumine	28,50	Lime	3,25
Oxide of iron	16,50	Oxide of manganese	0,25

By M. ACHARD.

Silex	48	Lime	11
Alumine	30	Iron	10

By M. WIEGLEB.

Silex	36	Iron	28
Lime	30		

XII. *Leucite.*

By M. KLAPROTH.

Silex	54	Pot-ash	22
Alumine	25		

By BERGMANN.

Silex	55	Lime	9
Alumine	39		

By Citizen VAUQUELIN.

Silex	53	Lime	2
Alumine	18	Pot-ash	18
Oxide of iron	6		

XIII. *Idocrase.*

Not yet analyzed.

XIV. *Feldt-*

XIV. *Feldt-Spar.*

By M. MORELL.

Silex	62	Sulphate of lime	10
Alumine	19	Water	2
Magnesia	4		

By M. WESTRUMB.

Silex	62	Sulphate of barites	2
Alumine	18	Water	2
Lime	6	Iron	1
Magnesia	6	Loss	3

By M. SCOPOLI.

Silex	63	Lime	2
Alumine	17	Iron	7
Magnesia	6	Water and Loss	5

By Citizen FABRONI.

Silex	55	Magnesia	4
Alumine	36	Iron	5
Barites	2		

Feldt-Spar. By M. MEYER.

Silex	74	Lime	0,1
Alumine	24	Iron	0,1

Green Feldt-Spar of Siberia. By Citizen VAUQUELIN.

Silex	62,83	Oxide of iron	1,0
Alumine	17,0	Pot-ash	16,0
Lime	3,0	Loss	0,15

XV. *Petro-Silex.*

By M. KIRWAN.

Silex	72	Lime	6
Alumine	22		

XVI. *Corindon.*

XVI. *Corindon.*

By M. KLAPROTH.

Alumine	84	Silex	6,50
Oxide of iron	7,50		

XVII. *Ceylonite.*

By Citizen DESCOTILS.

Silex	2	Oxide of iron	16
Alumine	68	Loss	2
Magnesia	12		

XVIII. *Axinite.*

By M. KLAPROTH.

Silex	52,7	Oxide of iron, and of	
Alumine	25,6	manganese	9,6
Lime	9,4		

XIX. *Tourmaline.*

By BERGMANN.

Silex	34	Lime	11
Alumine	54	Iron	05

Tourmaline of Ceylon. By Citizen VAUQUELIN.

Silex	40	Oxide of manganese	2,5
Alumine	39	— of iron	12,0
Lime	4	Loss	2,5

XX. *Amphibole.*

By M. KIRWAN.

Silex	37	Magnesia	16
Alumine	22	Iron	23
Lime	2		

By M. HEYER.

Silex	52	Lime	7
Alumine	23	Iron	17
Magnesia	6		

XXI. *Actinote.*

Not analyzed.

XXII. *Pyroxene.*

By Citizen VAUQUELIN.

Silex	52,00	Oxide of iron	14,66
Lime	13,20	Manganese	2,00
Alumine	3,33	Loss	4,81
Magnesia	10,00		

By BERGMANN.

Silex	58	Magnesia	1
Alumine	27	Iron	9
Lime	4		

XXIII. *Staurotide.*

By M. HEYER.

Silex	44	Alumine	20
Barites	24	Loss	12

Of Saint Gothard. By Citizen VAUQUELIN.

Alumine	47,06	Lime	3,00
Silex	30,59	Loss	4,05
Oxide of iron	15,30		

Of Britany. By Citizen DESCOTILS.

Silex	48	Lime	1,0
Alumine	27	Oxide of Manganese	0,5
Oxide of iron	9,5		

XXIV. *Thallite.*

XXIV. *Thallite.*

By BERGMANN.

Silex	64	Lime	9
Alumine	3	Iron	4
Carbonate of Magnesia	20		

By Citizen DESCOTILS.

Silex	37	Oxide of iron	17
Alumine	27	— of manganese	1,5
Lime	14	Loss	3,5

XXV. *Smaragdite.*

By Citizen VAUQUELIN.

Silex	50	Oxide of iron	5,5
Lime	13	— of chromite	7,5
Alumine	11	— of copper	1,5
Magnesia	6	Loss	4,5

XXVI. *Oisanite.*

It has not been analyzed.

XXVII. *Diopase.*

Not yet analyzed, suspected to be an ore of copper, according to some experiments of Citizen VAUQUELIN.

XXVIII. *Lazulite.*

By MARGRAFF.

Silex		Sulphate of lime	
Lime		Iron	

By M. KLAPROTH.

Silex	46	Sulphate of lime	6,5
Alumine	14,5	Oxide of iron	3
Carbonate of lime	28	Water	2

XXIX. *Zeolite.*

XXIX. *Zeolite.*

By BERGMANN.

Silex	60	Lime	18
Alumine	18	Water	4

By PELLETIER.

Silex	50	Lime	3
Alumine	20	Water	22

By MEYER.

Silex	58	Lime	6
Alumine	18	Water	17

By M. KLAPROTH.

Silex	44	Iron	5
Alumine	30	Water and air	2
Lime	18		

XXX. *Stilbite.*

By Citizen VAUQUELIN.

Silex	52	Water	18,5
Alumine	17,5	Loss	3
Lime	9		

XXXI. *Prehnite.*

By M. KLAPROTH.

Silex	44	Iron	5
Alumine	30	Water and air	2
Lime	18		

By Citizen HASSENFRATZ.

Silex	43,83	Iron	5,66
Alumine	30,33	Water	1,82
Lime	18,33		

XXXII. *Chabasite.*

This stone has not yet been analyzed.

XXXIII. *Analcime.*

XXXIII. *Analcime.*

It has not yet been analyzed.

XXXIV. *Sommite.*

By Citizen VAUQUELIN.

Silex	46	Oxide of iron	1
Alumine	49	Loss	2
Lime	2		

XXXV. *Andreolite.*

By M. KLAPROTH.

Silex	49	Alumine	16
Barites	18	Water	15

XXXVI. *Peridot.*

By Citizen VAUQUELIN.

Magnesia	51.5	Oxide of iron	9.5
Silex	38	Loss	2

XXXVII. *Mica.*

By Citizen VAUQUELIN.

Silex	50	Lime	1.33
Alumine	35	Magnesia	1.35
Oxide of iron	7	Loss	5.32

XXXVIII. *Cyanite.*

By SAUSSURE.

Silex	13	Magnesia	13
Alumine	67	Iron	5

By

471 COMPONENT PARTS OF STONES.

By M. STRUVE.

Silex	51	Lime	4
Alumine	30	Iron	5
Magnesia	5	Water and loss	6

XXXIX. Tremolite.

By M. KLAPROTH.

Silex	65	Oxide of iron	0,5
Lime	58	Water and carbonic acid	0,6
Magnesia	0,5		

XL. Leucolite.

By M. WIEGLEB.

Silex	50	Alumine	50
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XLI. Dipyre.

By Citizen VAUQUELIN.

Silex	60	Water	2
Alumine	24	Loss	4
Lime	10		

XLII. Asbestos.

By BERGMANN.

Sulphate of barites	6	Clay	3,3
Lime	6,9	Silex	64
Magnesia	18,6	Oxide of iron	1,2

By M. WIEGLEB.

Magnesia	48,45	Iron	4,79
Silex	46,66		

XLIII. Talc.

By M. KIRWAN.

Silex	50	Magnesia	45
Alumine	5		

XLIV. Chlorite.

XLIV. *Chlorite.*

By Citizen VAUQUELIN.

Silex	26	Muriate of soda, or pot-	
Alumine	18,5	ash	2
Magnesia	8	Water	2
Oxide of iron	43		

By M. HOEPPNER.

Magnesia	43,7	Alumine	4,1
Silex	37,5	Iron	12,8
Lime	6,2		

XLV. *Macle.*

It has not yet been analyzed.

XLVI. *Argil.*

Its analysis varies, because it is the stone, or earth, most capable of mixture; it approaches most to stones entirely, or completely mixed.

END OF THE SECOND VOLUME.





